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RINDERPEST, WITH SPECIAL REFERENCE TO ITS CONTROL BY A NEW METHOD OF PROPHYLACTIC TREATMENT

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THREE PLATES

GENERAL DISCUSSION

The new prophylactic, or vaccine, treatment for rinderpest, which is to be described in this paper, is the culmination of experiments and observations on that disease in the Philippine Islands from 1910 to 1924, during which time the writer was continuously employed as the veterinary pathologist of the Bureau of Agriculture.

Previous to 1921, the simultaneous method of immunization, the "serum-alone" treatment, and the "quarantine-alone" method had been employed in the Philippine Islands in combating rinderpest. Since that time the vaccine treatment has practically supplanted the first two and it is now used to supplement the quarantine-alone method.

A letter from Dr. Stanton Youngberg, present director of the Bureau of Agriculture, Philippine Islands, written in October, 1926, stated that, by January 1, 1927, over three hundred thousand head of cattle and carabaos will have received the vaccine treatment. By the use of this vaccine several provinces which had been considered enzoötic to rinderpest, in as much as the disease had resisted all other methods, had already been declared free.

The success we achieved in developing the vaccine treatment for rinderpest was not a one-man problem. In working out the minute details in the control of such a disease, we needed loyalty, coöperation and, above all, honesty. The late Dr. Ildefonso Patdu exemplified these qualities and, through his untiring efforts and enthusiasm, we made great progress in introducing the new treatment to his countrymen. Praise and credit are due to all the men who worked at the Veterinary Research Laboratory, as well as to the several veterinarians who used the vaccine in the field. Through their successes and also their failures, we worked out better methods of producing and administering the vaccine on a large scale. Due credit is given the late Director of Agriculture of the Philippine Islands, Mr. Adriano Hernandez, and to Dr. Stanton Youngberg, at that time chief veterinarian, for their aid in furnishing us with an abundance of experimental animals and additional equipment as the work advanced.

It has been observed that the best method of controlling rinderpest in infected areas is by the combination of quarantine and vaccination. A rigid quarantine is placed upon all animals, especially the exposed and sick. All susceptible animals are vaccinated and these, in the course of two or three weeks, become resistant to rinderpest. The infected ones either recover or die. When infected territory is declared free from the disease and the quarantine is raised, there is no chance of an immediate recurrence of infection as all the animals have become immune, either by passing through a natural attack of rinderpest or by the vaccine treatment.

In localities free from rinderpest the vaccine can be used with equal facility. Here no quarantine measures are necessary. Animals undergoing the vaccine treatment do not present any ill effects during the process of immunization. They do not develop a reaction by which they would transmit the disease to a susceptible animal. Draft animals can be worked every day without detriment to themselves or to the type of immunity developed. Dairy cattle show little or no subsidence in milk production during the vaccine treatment. The nervous type of dairy cow may show a slight depression for one or two days following vaccination, but the normal production is resumed promptly and without any further interference. Calves are immunized by the vaccine treatment as readily as are mature animals.

At this point, a review of the work that led to the development of the rinderpest vaccine will be given.

TREATMENT OF RINDERPEST WITH DRUGS

On May 30, 1911, experiments were started on the treatment of rinderpest with different drugs.(1) These experiments were carried out at various times during a period of approximately six and a half years. Twenty-seven preparations were used, and were administered in varying ways as to combinations, quantities, time of administration, etc. Over fifty animals were used, and but two of those treated recovered from the disease, which was positive proof that the drugs, as we administered them, had no curative power for an animal suffering from rinderpest.

Dr. Stanton Youngberg, the then chief veterinarian, and several veterinarians in charge of immunization stations in the provinces, used strychnine, nitroglycerine, and echinocoid on animals that had a severe reaction while passing through the simultaneous immunization. These workers found that all three of the drugs prolonged the life of animals by their stimulating effect and, in many instances, seemed to sustain life long enough for the development of sufficient antibodies to combat the disease, in this way enabling them to make a recovery. However, these drugs are practically useless for animals that contract rinderpest in the usual way without having previously received a protecting dose of serum.

From the results obtained it was quite obvious that either the virus of rinderpest was very resistant to the action of the drugs used or that the virus was so located in the body tissues that the drugs could not act upon it, the virus in the blood stream being merely a surplus thrown off from these body tissues.

LONGEVITY OF THE VIRUS OF RINDERPEST IN LEECHES

On July 13, 1912, experiments were started on the duration of the infectiveness of virulent rinderpest blood in the water leech, *Hirudo boyntoni* Wharton.(2) It was proved that the large water leech could retain the virus of rinderpest alive in its body for at least twenty-five days and in a virulent condition. A similar amount of virulent rinderpest blood kept in a cotton-plugged test tube under similar temperature conditions would lose its virulence in from seven to ten days.

From the results obtained in the experiments with leeches, it would appear that the virus of rinderpest needed partial or complete anaërobic conditions for its longevity and development. There was also a possibility that the virus was protozoan in nature, as several workers have performed similar experiments on protozoan diseases. Bass and Johns(3) cite the statements of Sakharov, Rosenbach, Blumer, Hamburger, and Mitchel, that they kept malaria plasmodia alive for several days in leeches that had been allowed to draw the blood of malarial patients. Laveran and Mesnil(4) state: "Various trypanosomes which were found by Brumpt in fresh-water fishes can be divided into several groups according to their mode of evolution in the bodies of leeches (Hemiclipsis)." Elsewhere they state, in discussing a trypanosome disease of horses in Annam, that Vassal(5) found that "The blood of leeches which had fed on infected animals was infective on injection into rats immediately after the meal of blood, but not four hours later. The trypanosomes are killed off very readily in the stomach of the leech." Daniels and Alcock(6) state: "Many parasites maintain their virulence for a considerable period in the stomach of leeches, but leeches are not known to act as carriers of disease." Nencki, Sieber, and Wijnikewitch(7) allowed leeches to feed upon animals infected with rinderpest. Later, they examined the blood in these leeches for the presence of the organism regarded by them as the causative agent of rinderpest, but without success.

With the results of the work in the Philippines with leeches in mind and noting the work on the cultivation of malaria by Bass and Johns,(3) also that of Nencki, Sieber, and Wijnikewitch,(8) experiments were started on the cultivation of the virus of rinderpest in vitro.(9) These results showed that it is possible that the virus of rinderpest requires either partial or complete anaërobic conditions for its existence.

EXPERIMENTS ON THE CULTIVATION OF THE VIRUS OF RINDERPEST

The virus of rinderpest was carried in virulent form in two separate series up to the sixth transfer in glucose-blood culture medium, covering periods of nineteen and twenty-one days, respectively. In one series, the original tube was nonvirulent at the end of twelve days, while the fourth transfer from this same tube of culture medium, after the same period of time, was virulent.

EXPERIMENTS IN ATTEMPTING TO LOCATE THE VIRUS IN THE SEPARATE BLOOD ELEMENTS

In the cultivation experiments, we also tried to locate, if possible, the blood element which harbored the virus. For assistance in this work, I was greatly indebted to Dr. M. A. Barber, of the Bureau of Science, who used his pipette method for the isolation of single microörganisms in picking out the separate and different blood elements.

Animals were injected with red blood cells alone, leucocytes alone, and blood platelets alone, which had been obtained from the blood of an animal sick with rinderpest. None of these separate elements affected the animals injected, though they were later proved susceptible. Whole blood taken from the same sick animal and injected in a 5 cubic centimeter dose into a susceptible animal, however, caused rinderpest.

ESTIMATION OF THE MINIMUM LETHAL DOSE OF VIRULENT RINDERPEST BLOOD NECESSARY TO TRANSMIT THE DISEASE

The question then arose as to whether the virus impregnated the blood of an infected animal to the extent that had been previously supposed. Experiments were carried out along this line and it was found that 1/2970 of a cubic centimeter of virulent blood transmitted the disease to a susceptible animal, but that 1/9060 of a cubic centimeter and 0.0001 of a cubic centimeter of virulent blood failed to transmit the disease. In summing up these experiments, it would appear that the virus of rinderpest is not intracorpuscularly located.

Braddon(10) described various bodies he observed in the erythrocytes from animals suffering with rinderpest, and considered these as the possible causative agent of the disease.

OBSERVATIONS ON THE NATURE OF THE VIRUS OF RINDERPEST

Tartacovsky(11) gave a thorough review of the results obtained by numerous workers up to 1896. Koch,(12) in 1897, in the second report of his investigations in South Africa on the etiology of rinderpest, states that all his efforts to isolate and cultivate the virus of rinderpest were fruitless.

Several experiments, which have heretofore not been reported by me, also gave some idea as to the nature of the virus of rinderpest. It was observed that by drawing blood from an animal sick with rinderpest direct into large test tubes and

allowing it to clot, the virus would retain its virulence for a considerably longer time in the blood clot than in a similar quantity of virulent blood which had been either defibrinated or citrated to prevent its clotting. Hens' eggs were injected with virulent blood and incubated at 40° C. A small portion of shell, approximately 4 millimeters square, was removed. Care was taken to see that the underlying membrane was left as nearly intact as possible. A finely drawn out pipette containing the virulent blood was then inserted through the egg membrane, rather deep into the egg, and the virulent blood expelled. The small square of shell previously removed was replaced and the area covered with high melting point paraffine. It was found that the virus remained in a virulent form for sixteen days in fertile eggs, but lost its virulence much sooner in nonfertile eggs. The same quantity of virulent blood, approximately 0.2 of a cubic centimeter, when placed in a test tube and kept under similar temperature, would lose its virulence in about three days. There results exemplified the necessity of at least partial anaërobic conditions for the virus to maintain its virulent properties for any length of time.

BLOOD CHANGES IN AN ANIMAL SICK WITH RINDERPEST

While studying the blood changes in animals infected with rinderpest it was observed that, in many cases, there was a slight increase in the number of leucocytes in the circulating blood just prior to the initial rise in temperature. With this rise, there was constantly a marked decrease in the number of leucocytes, which continued until the crisis of the disease. In the case of death, there was a marked increase. This condition was especially prominent when the temperature of the animal dropped to subnormal. If recovery was made, the leucocytes would rapidly increase to their normal number. Another constant blood change was in the platelets. These elements would become enlarged and granular, as if undergoing hydropic degeneration. Réfik-Bey(49) cites quite similar observations on the blood changes in cattle suffering from rinderpest in Egypt.

TRANSMISSION EXPERIMENTS ON RINDERPEST

A series of experiments bearing on the subject of the transmission of rinderpest, designed to simulate natural conditions as nearly as possible, was performed by Ward, Wood, and Boynton.(13) In combating rinderpest, information concerning

the length of time the virus remains active outside of the body under various natural conditions is of great importance in suggesting the measures to be employed in the field. Information concerning the period during the course of the disease when the virus is disseminated by the sick animals is of equal usefulness.

The literature on the disease consulted by us contains scanty and contradictory reference to these significant topics. Hutyra and Marek(14) give an extensive symposium on the views of various writers.

Réfik-Bey and Réfik-Bey(15) state the following: "Infected areas do not remain dangerous for long if we may believe our own observations. We regard rinderpest virus as essentially fragile and incapable of development in external media."

Edington(16) states: "Similarly the nasal mucus from a spontaneous case of rinderpest was found to lose its virulence very quickly if exposed to the air and kept for any period beyond 24 hours."

Stockman,(17) writing about the serum-alone method, observed: "The virulent material does not remain active for more than a day or two outside the animal body."

Yersin(18) states that two days of desiccation are sufficient to destroy the virulence of the blood.

Ruediger(19) states that pastures which have been occupied by sick animals may remain infected for months or even years.

In concluding our work, rinderpest virus was not shown to have survived beyond twenty-four hours in corrals bare of vegetation but containing water. The tests were made at all seasons of the year, with accompanying variation in sunlight, rain, and conditions of the soil; the amount of shade varied widely. Animals became infected in such corrals within half an hour, twelve hours, and seventeen and a half hours, respectively, after removal of the sick.

Animals infected with rinderpest, and also their blood, were shown to be capable of transmitting the disease by close contact only during the febrile period; however, during the convalescent stage, when the temperature was nearly normal, such transmission did not take place.

The virus in urine, diluted with water and sprinkled on grass, was in some instances demonstrated to survive for thirty-six hours, but not always. Fæces, mixed with water and sprinkled on grass, infected an animal twenty-four hours later. Fæces

and urine, diluted with water and kept in a vessel in the shade, remained infective for thirty-six hours, but not longer.

No evidence was secured to show that recovered cases transmit the disease.

The foregoing facts indicate that the virus of rinderpest perishes soon after discharge by an infected animal.

ATYPICAL CASES OF RINDERPEST

Further information concerning the action of rinderpest virus was obtained accidentally in choosing for experiment a carabao in which the disease ran an atypical course.(20) The purpose of the experiment was to determine if the blood of an animal which had been inoculated with virulent rinderpest blood was infective before the donor presented the first symptom of disease; namely, a rise in temperature. An incubation period of five days was regularly observed in the animals inoculated with the virus used at the laboratory at this time. Blood was obtained from this animal at forty-eight, seventy-two, ninety-six, and one hundred twenty hours after it was injected. Each bleeding was injected into a susceptible animal. Since the donor did not develop a fever on the sixth day after injection, the daily bleeding was discontinued, as it was feared the carabao was immune. On the ninth day after injection, this carabao developed diarrhœa and presented congested eyes, and the animals that received the forty-eight and seventy-two-hour blood also began to manifest symptoms of rinderpest. On the eleventh day after injection, this carabao refused food. It was again bled and the blood injected into another animal. Susceptible animals were exposed in a small corral to the sick carabao on the eleventh, twelfth, and thirteenth days, although it had died on the night of the twelfth day.

Rinderpest was developed in all of the animals that received blood from this carabao, but not in those that were merely exposed.

It was concluded that an animal may experience a fatal attack of rinderpest without the occurrence of a rise in temperature.

The blood of this animal was shown to be infected within forty-eight hours after it was originally injected with virulent blood. It was also shown that the blood was virulent on the eleventh day when injected into a susceptible animal, yet exposure to this animal did not transmit rinderpest to a susceptible animal.

Regarding the three animals which failed to contract rinderpest by exposure, the question is raised as to whether this disease spreads by contact readily in the later stages or whether it must necessarily be accompanied by a rise of temperature before it can be so spread. Littlewood,(21) in Egypt, has observed that cattle imported from Asia Minor may not show clinical symptoms and yet at autopsy reveal lesions of rinderpest. Rickmann,(22) writing of rinderpest in German South Africa, refers to the fact that cattle and other animals may be infected to an imperceptible degree. Eggebrecht(23) observed in China that some animals infected with rinderpest show no visible sign of the disease beyond a rise of temperature to 40° C., or higher, for two days. Baldrey,(24) describing conditions in India, states that by long residence of an organism of contagious animal disease in one place, the disease becomes weakened in virulence to the animals of that locality. Thus, animals infected with rinderpest may act as carriers without showing symptoms.

CULTURE EXPERIMENTS FOLLOWING BALDREY'S TECHNIC

Important facts were observed concerning the virus of rinderpest in experiments which were carried out in an attempt to verify its cultivation(25) as described by Baldrey, who stated(26) that antirinderpest serum can be prepared by the inoculation of virulent blood diluted with broth. Also, it appears possible that an active toxin is produced and excreted into the broth by the rinderpest organisms contained in the virulent blood, and that by this means the results recorded are obtained.

This material, or probable toxin, is rapidly excreted and is so active that it appears quickly to inhibit any further growth of the rinderpest organism, destroying its virulence and finally killing it. The substance so obtained is very much more active than that obtained in virulent blood, so much so that it cannot be given subcutaneously with safety on account of the extreme inflamatory condition it sets up.

In our experiments, following Baldrey's technic, we found that rinderpest virus does die in Martin's broth culture after incubation for seventy-two hours, but there was no evidence that a toxin is formed. The experiments further revealed that the virus will survive in neutral or alkaline Martin's broth at 37° C. for at least forty-eight hours, but not for seventy-two hours. Two cases were tested at twenty-four, two at forty-eight, and three at seventy-two hours. Virus kept in acid Martin's broth

or in 5 per cent potassium citrate solution did not survive after forty-eight hours at 37° C.

The principal phase which facilitated the development of the rinderpest vaccine was the fact that the virus survived longer in neutral or slightly alkaline medium than it did in an acid medium.

HISTORY OF RINDERPEST IN THE PHILIPPINES AND ITS CONTROL BY MEANS OF IMMUNIZATION, QUARANTINE, AND SLAUGHTER

At this point a partial review of the history and methods of handling rinderpest in the Philippine Islands will be given.

According to Youngberg(27) it is generally believed that rinderpest was introduced into the Philippine Islands in 1886 or 1887. It appears that the introduction was by means of carabaos imported from French Indo-China that were intended for breeding purposes. The disease spread to most parts of the Philippine Islands and caused enormous losses of cattle and carabaos. In many places, these losses were as high as 90 per cent. During 1901 and 1902, it is reported that 629,176 cattle and carabaos died of the disease.

In the Philippines, the severe epizoötics come in cycles of from eight to ten years. The first big wave was in 1887. The next, according to the most reliable information, was in 1897, and the third was well started in 1907. In 1916, the increasing death rate in provinces where the disease had been running a fairly mild course for several years gave indications that another big wave was forming.

During 1901 and 1902 the glycerine-bile method of producing immunity was tried to a limited extent. A serum laboratory was opened by the Board of Health and the production of antirinderpest serum was begun in August, 1902.

The problem in all rinderpest-infected countries was to find a method by which the cost of production of antirinderpest serum could be reduced.

Ruediger(28) found that he could increase the production of virulent material by giving peritoneal injections of normal salt solution, allowing it to remain for two hours before bleeding the virus animal to death, and then aspirating the saline solution from the peritoneal cavity.

Thomson,(29) to increase the production of virulent material, used normal salt solution peritoneal injections a short time be-

fore bleeding the animal to death, and then aspirated the saline solution from the peritoneal cavity.

Ward and Wood(30) found that the severity of the immunizing reaction could be controlled by the amount of serum employed, and that, while the serum from reactors is somewhat more potent than that from nonreactors, by increasing the dose of the nonreactor serum, the same results may be obtained. They further found that an animal may be immunized by simultaneous inoculation without showing either fever or symptoms. In later experiments and observations,(31) they show that it is not necessary to use hyperimmune serum at the immunization stations, and that potent serum can be obtained from animals which have just recently recovered from the disease. This method of obtaining serum for simultaneous immunizing purposes was used in the field for several years up to the time that the rinderpest vaccine began to be used.

Braddon(32) states that in South Africa the injection of uninfected animals with defibrinated blood from recently recovered pest cases was abandoned in favor of Turner's method of using serum from animals that had received successive and increasing doses of virus.

Turner(33) states that in the Transvaal and Natal an immune animal was injected with 100 cubic centimeters of virulent blood and was bled after all reactions had ceased. This blood, when defibrinated, was injected into a susceptible animal which was smeared on the muzzle with virulent material and placed with others suffering with rinderpest. This method of simultaneous inoculation, using blood prepared at the time, seems to have been abandoned in favor of a serum requiring more elaborate preparation.

Gibson(34) is the first writer who has questioned the necessity of hyperimmunizing serum-producing animals.

Shealy(35) makes a similar observation to the effect that the results obtained with the serum prepared from animals after recovery from an attack were found to be just as good as when the animal was not bled until it had been hyperimmunized.

Holmes(36) gives additional information regarding the overestimation of the value of serum from hyperimmunized animals. He concludes that the serum obtained after natural recovery or after an immunizing reaction is little inferior in potency to that taken after the process of hyperimmunization.

Topacio(37) gives a thorough description of the process of producing hyperimmune serum in the Philippines. He estimates that, as produced by the Bureau of Agriculture, it costs, delivered in the field, 24 pesos[1] (12 dollars) per liter. In the Transvaal, the cost was 25 pesos (12.50 dollars) per liter. The Bureau of Agriculture purchased serum from the Pasteur Institute at Nha-Trang, French Indo-China, at the rate of 47.89 pesos (approximately 23.95 dollars) per liter, and from the Experiment Station for Animal Diseases, Tokyo, Japan, for 34.40 pesos (17.20 dollars) per liter. With these prices, the least an animal could be immunized for was in the neighborhood of 8 pesos (4 dollars), and if it presented a severe reaction, the cost would amount to practically the price of a liter. In many instances, a liter of serum is required to save an animal. By using serum drawn from recently recovered animals, the cost is reduced to approximately 1.50 pesos (75 cents) per animal.

Kern(38) gives a thorough description of the precautions necessary to take in using antirinderpest serum in the field. He states that the animals that recover from attack of the disease produce a serum of varied degrees of potency, according to the reactions through which they pass during the disease. Those that present severe symptoms and high temperatures usually produce a serum of a very high potency, while that from those that pass through a mild form and run a low or no temperature is of less potency. He observed that carabaos produce a serum of higher potency than do cattle, probably due to the severe reaction suffered. It is found to be of highest potency about the ninth day after the animal recovers and gradually becomes less potent as the number of days increases until it is bled.

Nicolle and Adil-Bey(39) were the first to develop a method by which the virulent material could be increased. When an infected animal presented symptoms of diarrhœa, they introduced into the peritoneal cavity a mixture composed of three volumes of normal saline solution and one of a slightly alkaline solution of Martin's peptone. Six liters of this material were introduced into yearling cattle (the quantity varying according to the size of the animal). After three hours, the animals were bled to death, the peritoneal cavities were opened, and the fluid was aspirated. This was allowed to coagulate and the

[1] One peso Philippine currency is equivalent to 50 cents Unites States currency.

clear liquid was then drained off and used. The fluid that was thus obtained gave an increase in virulent material; this was used with success in hyperimmunization.

Ruediger(40) obtained similar results using a 5 per cent sodium citrate solution.

Holmes(41) diluted the virulent blood with an equal volume of potassium citrate solution and claims the diluted blood gave better results than undiluted defibrinated blood.

Martoglio(42) developed a method by which he claims to wash out the blood vessels and lymphatic system and to obtain a potent virus, increasing the virulent material about 70 per cent. His technic is as follows:

When the infected bovine presents the buccal lesions, usually at the end of the fourth or fifth day of the fever, less commonly at the end of the third, sixth, or seventh, it is immobilized in the stocks and intubed in the jugular and carotid on the same side. The jugular is put in communication with a capacious glass receptacle, placed on a level with the head of the animal and containing saline solution, sterilized, and held at a temperature of 38 to 39° C., leaving the outlet tube of rubber closed by compression of pincers. The carotid is put in communication with the receptacle that is to receive the pest blood, and the bleeding begins. When the convulsions preceding the death struggle begin, the bleeding should stop. The assistant shuts the tube for drawing the blood with a clamp and opens the tube admitting the sodium chloride solution; immediately the serious symptom-complex changes, the muscular contractions begin to cease, the respiration and pulse that were accelerated become regular, and the animal, when it has received about as much solution as it has lost blood, enters a period of calm.

We usually inject enough solution to make two and one-half times the volume of blood taken, without ill results. The operation over, the animal returns to its shed without assistance. After a lapse of about five or six hours, the animal is bled from the same carotid, this time until it dies.

Youngberg and Shaffer(43) used a simple method of slightly increasing the production of virulent blood as follows:

Two to 4 liters of blood are taken from the virus animal, depending upon its size, on the second day of fever. The animal is then allowed to stand overnight, during which time the body has an opportunity to replace the volume of blood lost. On the following day it is bled to death. In the final bleeding,

practically as much blood in bulk is obtained as would be procured in a single bleeding, which gives an increase in virulent material corresponding to the amount obtained at the initial bleeding.

Boynton,(43) in his work on organ extracts from rinderpest-sick animals, has obtained a filtrate of extracts prepared from the organs of a Batanes bull (virus animal) after bleeding it to death for virus. The total virulent material obtained from this animal was 9 liters of blood and 11 liters of filtrate. He states further that, by combining this method with that of Martoglio,(42) the total output of virus from this one animal would reach 26,300 cubic centimeters, or three times the quantity an animal of this type would produce had it only been bled to death.

Immunization of cattle and carabaos against rinderpest in the Philippine Islands with the simultaneous method has produced good results in districts where the disease is purely enzoötic. Its use is dangerous in rinderpest-free areas or in localities where the infection has recently been introduced, because the immunization stations are a constant focus of infection.

The serum-alone treatment as a general field measure against rinderpest is expensive and inefficient, as the protection it affords is of short duration (from ten days to three weeks), after which period the animals are as susceptible to reinfection as they were prior to the serum treatment.

At stations where animals were being immunized, many instances have been noted of the introduction of other diseases, such as surra, Texas fever, and anaplasmosis,(44) through the use of virulent blood taken from an animal which was a carrier of one or more of these diseases.

The quarantine and slaughter method of eradicating rinderpest was used in a few instances. Thomson(45) states that the success in eradicating rinderpest from Davao was attributed to adequate laws and ordinances of the province, which, coupled with the influence of the officials, enabled them to maintain the necessary rigid quarantine and to accomplish the slaughter of infected and exposed animals.

Similar methods were used in some of the provinces in northern Luzon,(27) but without success, as the farmers, rather than have their sick and exposed animals slaughtered, would not report the disease, would hide the sick ones, and would slip those that had been exposed through the quarantine lines at

night. As the Philippines, generally speaking, is an unfenced country, this was fairly easy to accomplish.

Quarantine, without slaughtering the sick and exposed animals, was extensively used in the Philippines with some good results. However, as soon as the quarantine was lifted, all the animals that had not passed through the disease were as susceptible to it as before and, in many instances, reinfection would occur and the quarantine would again be established. Such conditions were not satisfactory, either to the cattle owners or to the veterinarians in charge.

A STUDY OF THE VIRULENCE OF CERTAIN BODY ORGANS IN RINDERPEST

During January, 1917, experiments were started on the study of the virulence of body organs in rinderpest.(46) This work gave the first evidence of the possibility of developing a vaccine against that disease.

Since the virus of rinderpest could not be satisfactorily cultivated under artificial conditions, it was decided to try to extract it from the tissues of animals suffering from the disease. From the symptoms, lesions, and microscopical findings, it was evident that the virus attacked primarily the involuntary muscles, the endothelial lining of the capillary vascular system, and the parenchymatous tissue.

On reviewing the work accomplished up to this time, it was quite evident that the virus of rinderpest does not have its fountain head of development in the blood stream. The real place where it multiplies appears to be inside the tissue cells, where the disinfectants and drugs cannot penetrate, the virus in the blood stream being merely a surplus that is thrown off from these tissue cells. In following this line of reasoning it was decided to consider certain tissues, where lesions were more or less pronounced, as cultures, and extracts were made from them.

The tissues used were liver, spleen, lymph glands, heart, intestines, thymus, skeletal muscle, larynx, pharynx, and the base of the tongue. These tissues were taken from aniamls that were either bled to death for virulent blood or that had died after a regular course of the disease; they were taken as soon after death as possible. The amount of tissue desired was weighed and put through a meat grinder that had been previously sterilized to keep external contamination down to a minimum.

The material thus prepared was placed in a sterilized flask and twice as much phenol solution (the strength of which varied for different experiments) was added. Both crude phenol and the pure crystal form were used in these experiments with similar results. After preparation, the material was kept in the refrigerator, which averaged between 15 and 16° C., and it was thoroughly agitated two or three times daily. In some experiments, the material was placed in a shaking machine and agitated continuously for forty-eight hours at room temperature, which averaged 26° C. in the morning and 28° C. in the afternoon, some days rising to 30° C. It was then placed in the refrigerator for twenty-four hours, after which it was filtered through gauze to separate the coarse particles, and the filtrate was replaced in the refrigerator until used.

When the intestines were to be extracted, they were first thoroughly washed free from fæcal matter, then placed in a 5 per cent phenol solution for ten minutes, after which they were placed in a large container of boiled water which was cooled to at least 37° C. The tissue was allowed to soak in this water for a few minutes to dilute the phenol that remained intact. By this method a greater percentage of the bacteria on the surface of the intestinal mucosa was destroyed. Following this treatment, the tissue was weighed, passed through the meat grinder, and treated in a manner similar to the other tissue.

From the results obtained in these experiments, it was observed:

1. That water extracts of liver, spleen, and lymph glands, three days old, are highly infectious to susceptible animals.

2. That a 0.5 per cent phenol extract of liver, spleen, and lymph glands, five days old, is highly infectious to susceptible animals.

3. That a 0.5 per cent phenol extract of heart muscle, five days old, is highly infectious to susceptible animals.

4. That the skeletal muscle apparently is not suitable tissue for making extracts in the case of rinderpest.

5. That a 0.5 per cent phenol extract of liver, spleen, and lymph glands can hold the virus of rinderpest in virulent form for periods of time varying from eight to fifty-five days.

6. That a 0.5 per cent phenol extract of cæcum and colon, five days old, is highly infectious to susceptible animals.

7. That the larynx, pharynx, and base of the tongue are not suitable tissue for making extracts in the case of rinderpest.

8. That the pancreas is not a suitable tissue for making extracts in the case of rinderpest.

9. That a 1 per cent phenol extract of lymph glands, six, seventeen, and twenty days old, is highly infectious to susceptible animals.

10. That a 1 per cent phenol extract of liver, spleen, cæcum, and lymph glands, seventeen days old, is highly infectious to susceptible animals.

11. That a 1 per cent phenol extract of liver, twenty-one days old, is highly infectious to susceptible animals.

12. That a 1 per cent phenol extract of spleen, twenty-one days old, is virulent to susceptible animals.

13. That a 2 per cent phenol extract of spleen, five days old, is infectious to susceptible animals.

14. That when glycerine is added to a 2 per cent phenol extract that has been agitated for forty-eight hours, the virus of rinderpest is readily destroyed.

15. That in a 2 per cent phenol extract of lymph glands, eight days old, the virus of rinderpest is destroyed.

16. That the tissues best adapted for this work are the liver, spleen, lymph glands, heart, fourth stomach, cæcum, and colon.

17. That the virus in virulent rinderpest blood is readily destroyed when it is handled in a manner similar to the tissues.

In performing these experiments, we obtained some very gratifying results with old extracts. On these occasions, the animals presented no reaction to the injection. After a period of two weeks they were exposed to rinderpest by contact with sick animals, by inoculation with virulent blood, and by inoculation with extracts. No ill effects resulted from the exposures to which they were subjected, showing that they had been immunized by the primary injection of extract.

The fact was established that animals highly susceptible to rinderpest could be immunized against the disease without developing any of the severe reactions that frequently accompany the simultaneous method of immunization; also, that a solid immunity was produced as the experimental animals underwent the most severe exposure to the disease.

PROGRESS IN DEVELOPING THE RINDERPEST VACCINE

Our problem was to develop a method by which this material could be produced with regularity. From our observations, we decided to use the liver, spleen, and lymph glands as the most

suitable tissues. These were ground, extracted in a 0.75 per cent phenol solution, and kept in the refrigerator for thirty days. In some instances, we obtained good results; in others, the material was either inert or still virulent. We finally used 0.85 per cent sodium chloride solution instead of distilled water in preparing the phenol solution. After numerous experiments, it was also decided to titrate the carbolized salt solution to a point where it was slightly alkaline to litmus. Our next step was to obtain as much of the parenchymatous tissue as possible in the extract. To this end the tissue, after being passed through the meat grinder, was placed with sterilized sand in a mortar and thoroughly ground. Two parts of phenolized salt solution to one part of tissue were added, thoroughly mixed to bring the tissue into suspension, and allowed to stand for a few minutes to permit as much of the sand as possible to settle, after which the supernatant material was strained through gauze. The fluid, intermixed with the dismembered parenchymatous tissue, was passed through the gauze, while the connective tissue was held back. The filtrate was kept to be used in immunization experiments.

As the work developed, it was found that the best results were obtained from tissues taken from animals in the early stages of the disease, about the third day of fever, at the onset of diarrhœa. It was also observed that, by using salt solution instead of distilled water, the virus retained its virulence for a longer period. We had to hold the material for from sixty to seventy days before it was safe to use it.

The next problem was to shorten the time of preparing this prophylactic material, which was accomplished by using a simple type of shaking machine in which the material, placed in bottles, was agitated for forty-eight hours at room temperature. During the hot months of the year, it was found necessary to abandon the preparation of the material at ordinary room temperature, and a satisfactory place was found in the hallway of the ice and cold-storage plant of the Philippine Government, where a fairly even, cool temperature was maintained. From our observations on the influence of temperature, it was decided to heat the material to 44° C. in a water bath for three hours before agitating it in the shaking machine. During these experiments, it was also noticed that much better results were obtained when the material was kept in amber-glass bottles.

Up to this point we had made wonderful strides although the work had consumed the better part of two years. The material taken from an animal during the early stages of the disease, finely ground, suspended in either 0.5 or 0.75 per cent carbolized physiological salt solution which was faintly alkaline to litmus, strained through gauze to get rid of the connective tissue, placed in amber-glass bottles, heated to 44° C. for three hours in a water bath, and agitated for forty-eight hours in a cool room or at room temperature during the cool months of the year, could be used as soon as the process was completed. This product gave excellent and quite uniform results, but retained its immunizing properties for a short time only.

Since glycerine is used in preserving smallpox vaccine virus, we decided to add it to this material and found, after several trials, that it titrated to a point where it was slightly alkaline to litmus and, added in proportion of one part glycerine to three parts carbolized 0.85 per cent sodium chloride solution, enhanced the keeping quality of the material to a marked degree. It is of great importance to use only the best grade of glycerine as the inferior grades soon undergo changes and cause rapid deterioration of the material to which it is added. By the addition of glycerine, we were able to preserve this material in potent form for from five to six months when stored in the refrigerator in tightly stoppered bottles.

One of the problems that confronted us was to devise a method by which the tissue could be ground to a fine consistency without the use of the mortar and sand, as it was practically impossible to obtain a filtrate free from sand after passing it through this process and, in many instances, unsatisfactory results had been experience on this account.

In 1919, while the writer was in the United States, various supply houses were visited in search of some type of mill which would grind the tissues to the proper consistency. We explained our needs to Mr. Robertson Matthews, who was at that time assistant professor of mechanical engineering at Sibley College, Cornell University, and he immediately designed and made a tissue mill that produced the desired results. This mill both cuts and macerates, thereby breaking the tissue into minute elements. By this method we obtained a larger amount of vaccine material and a purer product, since it was free from sand and other contaminating material encountered in the mortar process.

TESTING FOR THE PRESENCE OF AGGRESSINS

The question then arose as to whether we were dealing with an aggressin or a vaccine. We had observed on numerous occasions that, if an animal in the incubation period of rinderpest or in the early stages of the disease was injected with this material, the disease was greatly aggravated and ran a rapid and fatal course.

Through the courtesy of Director E. D. Merrill and the assistance of Dr. Otto Schöbl and Mr. A. H. Wells, of the Bureau of Science in Manila, some of the material was run through a Sharpless centrifuge, by which method the liquid and the solid components were separated. On testing these separate products, it was found that the liquid constituent had no immunizing power, while the solid component, made up of the parenchymatous tissue, was potent and gave excellent results. It was, therefore, quite definitely settled that we were dealing with a vaccine or modified virus in the tissues and not with an aggressin. We also observed that the vaccine held its potency somewhat longer when separated from the liquid and that the protecting dose was considerably smaller. With the former material, the immunizing dose was 50, 100, or 150 cubic centimeters, depending upon the size and age of the animal. With the separated tissue, however, we found that 2 grams suspended in 35 cubic centimeters of a glycerinated diluting fluid, administered in two weekly doses, gave excellent results.

We then performed an experiment in which we followed Bail's technic(50) for using exudates from an animal to produce serous aggressins. It was noticed on numerous occasions that, if a large amount of virulent tissue extract (1 liter or more) was injected subcutaneously into an animal, in one or two days an œdematous swelling would develop on the pendant portion of the chest and belly, such swelling being filled with a clear, straw-colored, serous exudate. A susceptible animal was inoculated with virus and, at the first symptom of rinderpest (a rise in temperature), it was injected subcutaneously on both sides of the body with 2 liters of freshly prepared virulent tissue extract. In two days, confluent œdematous swellings were observed along the pendant portion of the body; this was at the most virulent stage of the disease, the third day after the initial rise in temperature. The animal was then killed, the œdematous tissue procured, and the liquid expressed by the aid of a meat press. To this fluid was added enough phenol,

drop by drop, to make a 0.5 per cent dilution of the entire solution. In order to prevent precipitation, the solution was agitated continually and then heated to 44° C. for three hours in a water bath. This solution was used in 5- and 10-cubic-centimeter doses on a few animals. Upon exposure to infection they showed a slight reaction followed by prompt recovery, indicating that the protection afforded by this material was not as complete as the immunity produced by the vaccine. Whether we were dealing with an aggressin in this instance or with a modified virus is an unsettled question. Since such a small amount of this material could be obtained from an animal and since it was not as effective for immunization purposes as were the tissue extracts, this line of experimentation was discontinued.

In searching for a simpler method of preparing a more-potent vaccine with better keeping qualities, it was decided to use the blood from the virus animals with the tissue and to use less sodium chloride solution. By this procedure the amount of virus was increased, and the vaccine was preserved in its normal medium. With this advance the Sharpless centrifuge was no longer necessary.

PREPARATION OF THE RINDERPEST VACCINE

The final procedure in preparing the rinderpest vaccine was as follows:

A highly susceptible animal was infected with the disease by injecting it with virulent blood, and was kept under close observation. As soon as symptoms of diarrhœa developed, which was usually on the third or, in some cases, the fourth day after the initial rise in temperature, it was bled to death and the blood retained in a sterile container. The animal was skinned and washed with a good disinfectant solution to keep external contamination down to a minimum. It was then eviscerated and all the lymph glands, spleen, liver, heart, kidneys, and testicles were placed in sterile containers and transferred to the laboratory. The fat, heavy connective tissue, and fascia were removed from these organs, which were washed in sterile water and, in order to destroy any contaminating organisms that might have been deposited during handling, were placed for ten minutes in a 5 per cent solution of phenol, after which they were again washed with sterile water to remove any excess solution. They were then cut into small pieces, passed through a meat grinder, and this finely ground material was

further ground in the Matthews's tissue mill. To obtain the maximum results, it should be ground in this mill two or three times. The grinding process was facilitated by the addition of blood from the animal, and a small amount of sterile glycerinated salt solution (glycerine, 1 part, and 0.85 per cent sodium chloride, 2 parts, titrated to p_H 7.6–7.8) may also be added for this purpose; care should be taken to use no more than is necessary, however. The macerated material was next strained through a 1/12-inch-mesh wire screen (a finer mesh may be used; a coarser one, however, is not advisable) which retained the connective tissue and coarser elements and allowed only the parenchymatous tissue to pass, and this was saved for vaccine.

Pure phenol to make a 0.5 per cent suspension in the mixture was added to an amount of sterile glycerine, p_H 7.8, equivalent to one-third the weight of the tissue. This phenol-glycerine and the tissue material were then thoroughly mixed to insure uniform consistency; for example, to 900 grams of tissue, 300 cubic centimeters of glycerine and 6 cubic centimeters of phenol would be added. The resulting material was then poured into slender-bodied, amber-glass bottles to about five-sixth of their capacity, and the cotton plugs replaced. The type of bottle used at the Veterinary Research Laboratory at Pandacan, Manila, was of 500-cubic-centimeter capacity, although the 450-cubic-centimeter amber-glass lysol bottle is also suitable for this work. The greatest care must be exercised to prevent any of this highly virulent material from coming in contact with the inside surface of the neck of the bottles or from splashing above the point to which the bottles are filled.

The filled bottles were placed in an electrically heated water bath. It is best to have the bottles immersed to their necks, as the water must reach well over the level of the tissue mixture. When all the bottles were in the bath, the electricity was turned on and the temperature of the water brought to 42 to 42.5° C. When the 42° mark was reached, the time was noted and the water bath held at the temperature as above stated (42 to 42.5° C.) for three hours, when the bottles were taken from the bath and the contents of each emptied into a large sterile container. The material was again thoroughly mixed by agitating it for two or three minutes to insure as nearly as possible the same degree of potency in each cubic centimeter. Fresh sterile bottles were filled with the vaccine and stoppered with tightly fitting corks. This concentrated rinderpest vac-

cine must be stored in a refrigerator or good ice box until it is used.

Although the liver, heart, kidneys, and blood contain an abundance of virus, they are not suitable tissues when used separately or collectively; but, when added to the lymphatic tissues and spleen, they form a vehicle which increases the yield of vaccine to a marked degree. By the addition of these organs, the average virus animal furnished approximately 6,000 cubic centimeters of vaccine.

VARIATIONS IN THE STRENGTH OF THE VACCINE

Variations in the strength of the vaccine can be produced as follows:

1. By heating the material to 41.5° C. for three hours; however, the effect of this upon an animal is likely to be a more or less severe reaction. If such material is stored in a refrigerator for three or four months, age will gradually attenuate it, rendering it safe for use.
2. By heating the material from 43.5 to 44° C. for three hours. Vaccine prepared in this manner can be used soon after its preparation, but it loses its potency more rapidly and larger doses are required.
3. By holding the temperature between 44 and 45° C. for three hours. This is likely to destroy the potency of the vaccine.

METHOD OF TESTING AND ADMINISTERING THE VACCINE

Each lot of vaccine must be tested on highly susceptible animals before it is used in the field.

With a potent vaccine, 2 cubic centimeters of the concentrated material are sufficient for fully developed cattle and carabaos. Each dose is diluted to 20 cubic centimeters in a sterile diluting fluid, composed of two parts 0.85 per cent sodium chloride solution and one part glycerine, and titrated to p_H 7.8. The area is disinfected and the injection of 20 cubic centimeters is made on either side of the animal, preferably over the ribs. This amount is used as, with massage, it insures a good spread of the diluted vaccine under the animal's skin and thereby facilitates rapid absorption. The needle puncture is painted with either dilute pine tar or tincture of oidine.

Seven days after the first vaccination, a second injection is given on the opposite side of the body. The dose of concentrated vaccine may be increased to 3 or 4 cubic centimeters. A week following the second treatment, the animal may be exposed to

rinderpest by placing it in direct contact with others sick with the disease and by giving it a subcutaneous injection of from 5 to 10 cubic centimeters of virulent blood. When the test animal passes through these exposures without developing any signs of infection, the vaccine is considered effective and may be used in the field; the dosage is 2.5 to 3 cubic centimeters of the concentrated material.

If the test animal gives a slight reaction to the above-mentioned exposures, the field dose should be raised to 5 or 7 cubic centimeters of the concentrated vaccine. No set rule can be given as to the exact size of the dose; however, the person preparing such material soon develops ability, from experience and observation, to estimate the amount which should be used of the different lots of vaccine as they are tested out. Moreover, rinderpest vaccine loses its potency with age. If a lot, potent in 2-cubic-centimeter doses at two months of age, is held for four or five months, it may be necessary to raise the dose to 5 or 7 cubic centimeters to obtain the same protection. The vaccine has no curative effect on an animal sick with rinderpest or in the incubation period of that disease. It is a purely prophylactic treatment.

LENGTH OF IMMUNITY DEVELOPED BY THE VACCINE

The length of immunity developed by the vaccine is not definitely known. From field observations, it has been noticed that, with animals receiving three treatments of potent vaccine, the protection has lasted for three years and even longer. Several of our test animals were immune to rinderpest after four and a half years. With our present knowledge, however, it would be advisable to revaccinate full-grown animals every two years. Calves should be revaccinated the following year and every two years after that time. Our experience in the Philippines has taught us that young animals, no matter by what method they are immunized, have a tendency to outgrow their immunity.

METHOD OF USING VACCINE IN INFECTED AREAS

When the vaccine is used in infected areas, we have found that it is helpful to apply general quarantine measures. The owners of animals will submit them for treatment more readily in order to hasten the lifting of the quarantine. It is also easier to keep track of the animals and to know that they return for their second vaccination, or third if the necessity arises.

We have had splendid success in smothering the disease on numerous occasions by the combined use of vaccine and quarantine. Areas have been declared free from rinderpest in which it had been considered enzoötic and all other methods of combating the disease had been resisted.

Care should be exercised not to vaccinate any animal that is sick or in the incubation period. The vaccine will only aggravate the disease in such instances and will be considered responsible for the death of the animal. We found it a wise procedure, when working in such localities, to take the temperature of all animals before they were vaccinated. Any animal with a high temperature should be rejected, for undoubtedly such a one under these conditions is developing the first symptom of rinderpest.

RESULTS OF THE USE OF VACCINE ON VARIOUS BREEDS OF CATTLE

The vaccine was used with success not only on Philippine cattle and carabaos but also on cattle imported from the United States and Australia for dairy and breeding purposes. We have vaccinated Herefords, Ayreshires, Jerseys, Guernseys, Holsteins, and mixed breeds. Many of these animals came from areas free from Texas fever. It would have been impossible to immunize them by the simultaneous method, as practically all the animals used for virus are carriers of that disease and it would be transmitted in the virulent blood. There is, however, a possibility that carabaos do not contract or transmit Texas fever. This is a problem that should be investigated. Carabaos are evidently resistant also to anaplasmosis,(44) a disease quite similar to Texas fever.

Rinderpest vaccine was used with equally good results on animals at the Canton Christian College in Canton, China, and at the Hongkong Dairy Farm, Hongkong, China.

COST OF IMMUNIZATION BY THE VACCINE METHOD AS COMPARED WITH OTHER METHODS

In figuring the cost of immunizing animals by this vaccine method, estimates were made of the purchase price and maintenance of the animals used to furnish material for the vaccine, the chemicals, and the labor of producing and administering the vaccine and its transportation. When a large number of animals were treated at one locality, the cost amounted to approximately six centavos, or three cents gold, per animal. This is an enormous saving as compared with the prices cited above

for either reactor or hyperimmune serum used in the simultaneous method of immunization.

Not only is the low cost of immunization by the vaccine treatment to be considered, but also the economy of time and animal labor to the owner. Animals immunized by the simultaneous method must be taken to an immunizing station where they are kept under observation throughout the process, which lasts three weeks or longer, depending upon the severity of the reaction. During this period, the owners are responsible for their maintenance, which is quite a problem in many instances. With the vaccine treatment, the animals remain at home and may be worked every day or used for any purpose the owner may desire, without detriment to the animal or the type of immunity developed.

When animals to be vaccinated were not too far from the laboratory, the vaccine was diluted ready for use and placed in thermos bottles. By this means the vaccine was kept cool and would not deteriorate for at least thirty-six hours. When, however, the animals were at a considerable distance from the laboratory, or on other islands of the Philippine group, it was found best to ship the concentrated vaccine, well packed in ice, to a central point in that locality where ice could be obtained. A temporary laboratory was installed, where the vaccine was diluted ready for use, placed in thermos bottles, and shipped out. By this means we were always sure of using a freshly prepared vaccine.

RINDERPEST VACCINE DEVELOPED BY OTHER INVESTIGATORS

Kakizaki, Nakanishi, and Oizumi,(47) investigating rinderpest in Korea, have developed a vaccine for which they claim good results. Their technic in some respects differs from the method described in this paper, although the principles involved are practically the same. Many of their observations are quite similar to ours. They found the tonsils to be the most satisfactory tissue for vaccine material; that made from the lymph glands seemed to be somewhat inferior. Apparently the only tissues they used were the tonsils, lymphatic glands, and possibly the spleen, which made their output from each animal small. They claimed a period of preservation for their vaccine of from two and a half to three and a half years, which is longer than we were able to preserve a potent vaccine made from a mixture of the various organs mentioned in our technic.

In the April number of the Journal of the American Veterinary Medical Association for 1927, it is reported that Maj. R. A. Kelser,(48) who is now stationed in the Philippines, is making further developments in perfecting rinderpest vaccine. No details of his method are given; therefore, no comment can be made. It is gratifying, however, to learn that our years of labor and observation have contributed to further success along this line.

A full report of the technic of preparing and administering the rinderpest vaccine as described in this paper was delivered to the Director of the Bureau of Agriculture, Philippine Islands, on March 10, 1924, to be filed as a ready reference for the continuation and further development of the vaccine method of immunizing animals against rinderpest.

Kakizaki, Nakanishi, and Nakamura,(54) in their later report, find that by combining such organs as the spleen, lymphatic glands, thymus, and tonsils, a more economical and potent rinderpest vaccine can be produced. They also added lung tissue to some of their preparations, but found it less efficacious than those lacking it. They state further: "It will be worthy of note that, by employing the combination method, the preparation of vaccine was highly improved, and the quantity of vaccine which can be prepared from one calf was amounted up to twice as much as before. For this reason we should like to designate the vaccine prepared by the combination method as 'the economical rinderpest vaccine'."

MISCELLANEOUS

The observations on the plurality of the virus of foot-and-mouth disease made by Valleé and Carré,(51, 52) and confirmed by Olitsky, Schoening, and Traum(53) in their reports on the study of foot-and-mouth disease and vesicular stomatitis in Europe, are of great importance. Their citations bring to mind some difficulties we had in making a potent rinderpest vaccine from the tissues of animals imported from Indo-China. Shipments of cattle and carabaos were landed at the quarantine station at Pandacan, Manila, that frequently were infected with rinderpest upon arrival, many of the animals being in such condition that they had to be slaughtered. On several occasions tissues were procured from these animals and vaccine prepared from them. In none of the trials, however, were we able to produce a vaccine that would protect animals against the virus

we were using at the laboratory, and we concluded that the imported animals were too far advanced in the disease to produce vaccine, as we had learned from previous experience that the best vaccine is obtained from tissues taken from animals in the early stages of rinderpest. Since the results obtained by Olitsky, Schoening, and Traum, however, we must consider the possibility that these animals were infected with a strain of rinderpest virus which would not immunize them against the strain of virus with which we were working in the Philippine Islands. Further work along these lines is necessary before definite conclusions can be formed.

Before leaving the Philippine Islands, we prepared some virulent rinderpest material, composed of liver, spleen, lymph glands, heart, and blood, obtained from an animal in the early stages of the disease. This material was put through the Matthews's tissue mill, and one-third per weight of glycerine p_H 7.8 and enough phenol to bring the entire bulk to 0.5 per cent were added. This material was bottled, tightly corked, and placed in the refrigerator, where it was kept for virulence tests. A letter from Doctor Patdu stated that he had tested this material at various intervals and had killed five test animals with it. He found it still virulent at the end of 271 days. Just how long it remained virulent, however, is not known, as the experiment was interrupted by the untimely death of Doctor Patdu.

CONCLUSIONS

1. From years of observation and the large number of animals that have been protected, it is evident that a potent vaccine against rinderpest can be made from certain body organs of animals suffering from this disease.

2. The lymphatic tissues are of primary importance as components of this vaccine.

3. Although the liver, heart, kidneys, and blood contain an abundance of virus, they are not suitable, either separately or collectively, for the production of vaccine; but, when these tissues are added to the lymphatic tissues, a potent vaccine can be produced from the entire mass.

4. The virus of rinderpest is thermolabile, and a temperature of over 44° C. is detrimental to the vaccine if such temperature is held for any length of time.

5. Animals immunized by the vaccine treatment do not undergo any noticeable systemic reaction. They can be worked

every day and cohabit with susceptible animals without detriment to themselves or to the animals with which they come in contact.

6. In the neighborhood of 6,000 cubic centimeters of vaccine can be obtained from one virus animal. This amount is sufficient to protect one thousand or more animals, depending on the titration of the vaccine. Thus, by the vaccine treatment, we have developed a safe and inexpensive method of protecting animals against rinderpest.

7. In using the vaccine in rinderpest-infected areas, it is essential to combine the vaccine treatment with quarantine measures.

8. When vaccine is applied to animals in rinderpest-free areas, there is no need of the enforcement of quarantine.

9. It is advisable to have all animals revaccinated every two years.

10. By the use of the vaccine, rinderpest has been eradicated from certain localities in the Philippine Islands, where the disease had resisted all other measures of control.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Passing the ground up tissue through the Matthews's tissue mill. All the bottles, the implements, and the tissue mill are throughly sterilized before being used.

2. Passing the ground up and mascerated tissue through the wire strainer. The strainers fit inside the large funnels. The material to be saved for vaccine passes into the large bottles. All implements are throughly sterilized before being used.

PLATE 2

FIG. 1. Filling the amber-glass bottles with the virulent tissue mixture. Care must be taken that none of this virulent material splashes onto the inside of the neck or the unfilled portion of the bottles.

2. Heating the vaccine in the electric water bath. The level of the water should stand halfway on the necks of the bottles to make sure that the vaccine gets the full benefit of the heat.

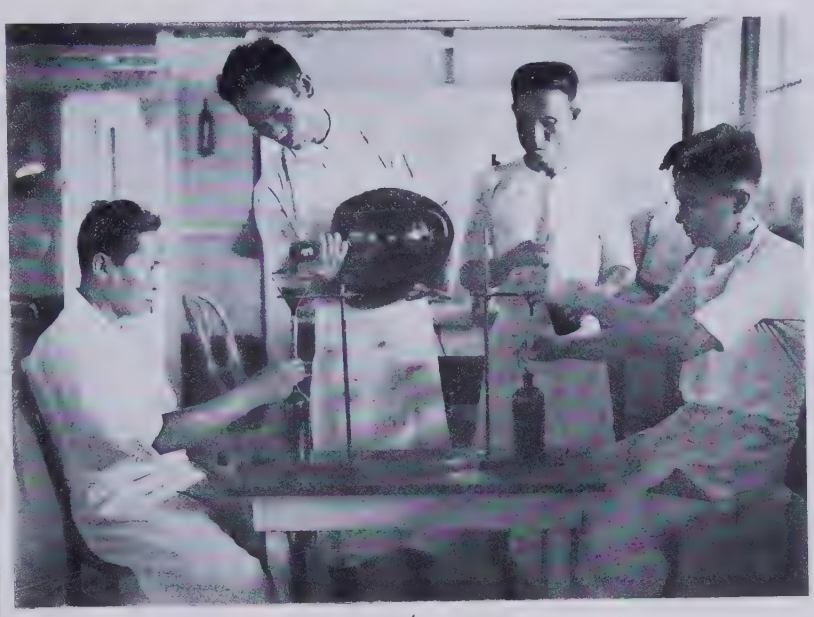
PLATE 3

The method of administering the rinderpest vaccine.

1

2

PLATE 1.



1

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PLATE 2.

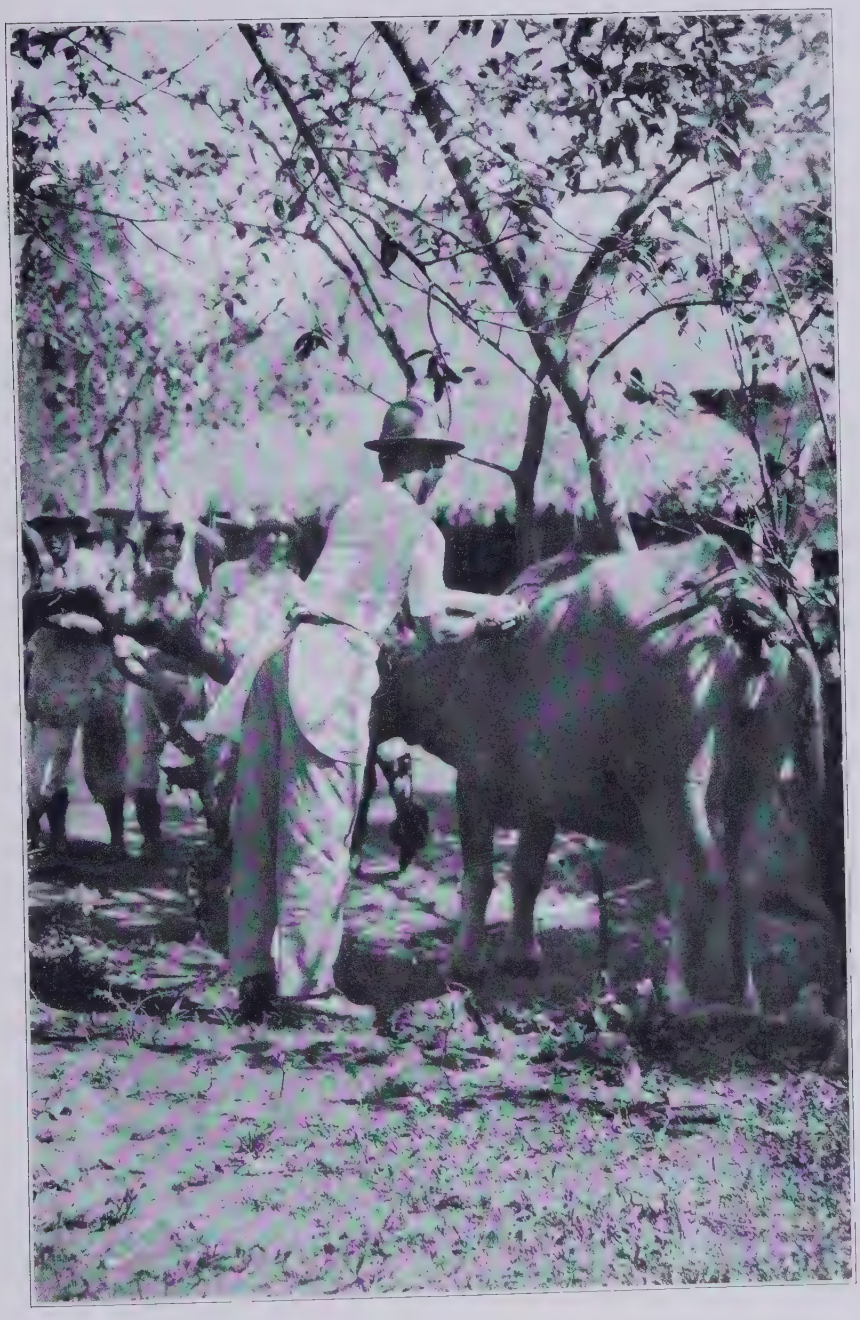

PLATE 3.

LARVAL TREMATODES FROM PHILIPPINE SNAILS

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FIVE PLATES

The larval trematode fauna of the Philippine Islands has not been investigated previously; yet, there are in this country several species of adult trematodes long known to be parasitic in man and in some of the domesticated animals. Among the most important of such trematodes may be mentioned *Schistosoma japonicum, Paragonimus westermanii,* and *Fasciola hepatica.* Although the modes of development of these parasites are already known in other countries, where they also occur, in the Philippines their molluscan intermediate hosts remain to be determined. There are, therefore, two reasons which led to the inquiry reported in this paper: first, to fill up partially the gap existing in the recorded fauna of the Islands; and, second, to make use of the results of the inquiry as a basis for future attempts to find out the life histories of some of the Philippine flukes.

The following, widely distributed, fresh-water snails were examined: *Melania* sp., *Melania asperata philippinensis* Sowerby, *Vivipara angularis* Miller, and *Ampullaria lagunaensis* Bartsch. From *Vivipara angularis* not a single cercaria has thus far been found, but from the three other species of snails nine different forms of larval flukes have been recognized and these are described below.

CERCARIA PARVOMELANIAE sp. nov. Plate 1, figs. 1 and 2.

Host, *Melania* sp.
Location, liver.
Locality, Los Baños, P. I. (Molawin Creek.)
Percentage of infestation, 4 to 6, June to September, 1927.

This cercaria is allied to the members of the Pleurolophocerca group of monostome cercariæ created by Sewell (1922) and is most similar to that author's Indian form designated by him as *Cercariae Indicae* VII. In open water this larva is a very active swimmer, moving from place to place with lightning velocity. It does so by curling its body ventrally, which is then propelled forward by means of the strong lashing movements of the powerful tail. Periods of active swimming generally alternate with periods of apparent rest, during which time the larva lies flat on the substratum with both body and tail performing a peculiar lateral shivering motion. When prevented from swimming, as under a cover glass, it moves vigorously by means of the active contraction and extension of the body muscles aided by the oral sucker.

The body, being capable of a considerable amount of contraction and extension, varies in shape accordingly. It is often flask-shaped when extended and pyriform when moderately contracted. During the latter state it measures from 0.09 millimeter by 0.06 millimeter to 0.13 by 0.10. It is transparent and of a greenish hue, which is imparted by the numerous coarsely granular cystogenous glands that are widely scattered in the parenchyma. It is covered anteriorly up to the level of the pharynx with small backward-pointing spines and bears on the dorsal surface of the anterior third of its length two conspicuous dark eyespots. The tail, which is attached on the ventral aspect of the posterior end of the body, varies greatly in length. When completely relaxed, it is from two to three times as long as the body. It is provided with a pair of lateral cuticular fins, which occupy the anterior third of its length; a dorsal fin, which starts from a level behind the termination of the lateral fins; and a ventral fin, which is about half as long as the dorsal fin. The dorsal and ventral fins extend and unite beyond the tip of the tail. When this organ is contracted, the lateral fins become folded and give the false impression of being supported by raylike structures.

The oral sucker, or penetrating organ, as Sewell prefers to call it, is nearly spherical in shape and measures 0.025 millimeter in transverse diameter. As in *Cercariae Indicae* VII, it is protrusible and invertible and is provided dorsally behind its extreme tip with a transverse row of spines. The mouth is subterminal in position. In some specimens a small, poorly developed pharynx is seen immediately behind the oral sucker.

There are eight pairs of finely granular salivary glands[1] arranged as in *Cercariae Indicae* VII, between the eyespots and the excretory bladder. The ducts of these glands pass anteriorly on both sides of the pharynx and open at the anterior dorsal region of the oral sucker.

The parts of the excretory system which I was able to detect are the following: The excretory bladder which is either transversely oval or bicornuate, depending upon the general shape of the body, and which discharges its contents outside through a small excretory pore situated on the dorsal surface at the junction of the body and tail; two main lateral collecting tubes arising from the anterolateral sides of the excretory bladder; a caudal collecting tube going into the tail from the posterior diverticulum of the excretory bladder; and two pairs of flame cells located as shown in Plate 1, fig. 1. There are undoubtedly other flame cells, but which I was unable to detect owing to the presence of the cystogenous glands which obscure the internal structure of the body and to the fact that the larva dies soon after it begins to quite down.

The reproductive system is represented by a mass of small roundish cells found in the space bounded by the salivary glands and the excretory bladder.

Development takes place in simple elongated radiæ, the mature ones of which contain from 8 to 10 cercariæ in various stages of development. The mature rediæ measure from 0.41 to 0.73 millimeter in length by 0.09 in width, while the immature ones average about 0.23 by 0.04 in size. A conspicuous pharynx is present followed, in young rediæ, by a long capacious rhadocœle gut. In mature rediæ the intestine is short and sometimes apparently absent, being crowded and hidden by the inclosed cercariæ.

CERCARIA REDICYSTICA sp. nov. Plate 1, figs. 3, 4, and 5.

Host, *Ampularia lagunaensis.*

Location, reproductive glands.

Locality, Los Baños, P. I. (Irrigation canal at the Experiment Station, College of Agriculture, University of the Philippines.)

[1] I have followed Sewell's designation, salivary glands, for the large unicellular structures, usually found in the middle and posterior parts of the bodies of larval trematodes. The term penetration glands, used by Miller (1926) with reference to the furcocercous cercariæ, may not be applicable in the case of other larvæ which do not penetrate into the bodies of their final hosts.

Percentage of infestation, 2, August, 1927.

This larva is a moderately active swimmer. Under a cover glass it is actively motile, quieting down only when near the point of complete dryness and death. It is related to Sewell's *Cercariae Indicae* XLI and, therefore, belongs to that author's "Agilis" group of distome cercariæ.

The unarmed, pyriform body is attenuated anteriorly, its maximum diameter being immediately in front of, or opposite, the acetabulum. It is packed with numerous, roundish cystogenous glands which are filled with rodlike bodies, arranged parallel to one another. The tail is massive and is attached on the ventral aspect of the posterior end of the body.

The two suckers are well developed, the ventral sucker located between the third and last fourths of the body length. In favorable specimens I was able to observe small, delicate, triangular spines arranged in circular fashion on both the oral and the ventral suckers, as shown in Plate 1, fig. 3. They are difficult to detect because the suckers are contracted most of the time and are, therefore, hidden from view. The cavity of the oral sucker leads into a prominent prepharynx, which is followed in succession by an oval pharynx and a very short œsophagus which divides into two short cæca. The measurements of these organs as well as of the moderately extended body and tail under different conditions are as follows: In living specimens, body 0.331 by 0.196 millimeter, tail 0.312 by 0.065 (at base), oral sucker 0.054 (transverse diameter), acetabulum 0.061 by 0.070, prepharynx 0.025 (length), pharynx 0.022 by 0.018, œsophagus 0.007 (length); in stained mounted specimens, body 0.225 by 0.097, tail 0.190 by 0.024, oral sucker 0.040, acetabulum 0.045 by 0.047.

The mouth is surrounded by a pattern of small, papillalike structures that are closely set together. On the dorsal lip of this opening there were observed, at least ten small, round spots, which are probably the terminations of the salivary glands, but the connections of which I was unable to follow. Neither did I succeed in determining the exact number of the salivary glands, of which I saw several pairs on each side of the pharynx and behind the intestinal cæca, due to the densely crowded cystogenous glands.

The excretory bladder, which opens outside through a median dorsal pore, is oval in outline, but at times it is constricted so that it becomes divided into anterior and posterior chambers.

Anterolaterally it gives off two main lateral collecting tubes which reach anteriorly as far as the level of the pharynx, from where they loop back and at a level anterior to the acetabulum they divide into anterior and posterior collecting tubules. These main lateral tubes are filled with rounded, fatlike masses, which probably represent excretory products. The caudal collecting tube, as usual, arises from a posterior diverticulum of the excretory bladder. Seven pairs of flame cells in the position shown in Plate 1, fig. 3, were seen, but it is possible that other cells escaped detection owing to the presence of the cystogenous glands. The general structure of the excretory system is, however, similar to that of the echinostomes, and because of this and together with the presence of spines on the suckers it is possible, as enunciated by Sewell, that this and related larvæ occupy a position among the echinostomes.

The reproductive system is represented by a group of cells lying ventral to the acetabulum.

This cercaria develops in rediæ which possess a posterior pair of locomotor appendages. The young rediæ, 0.47 by 0.087 millimeter in size, are actively motile, while the mature ones, 2.12 by 0.41 in size, are less so. One characteristic feature in connection with this cercaria is its ability to encyst while still inclosed within the redia. I have seen as many as five cysts thus formed within a redia. They are slightly oval in shape, with thick walls, and measure from 0.151 by 0.129 millimeter to 0.160 by 0.136.

CERCARIA PHILIPPINDICA nom. nov. Plate 2, figs. 1, 2, 3, 4, and 5.

Host, *Melania* sp.

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentage of infestation, only one snail among thousands examined during July, August, and September, 1927.

This large cercaria is plainly visible to the unaided eye. In its behavior and general morphology it resembles the members of the Megalurous group or heavy-tailed cercariæ proposed by Cort (1915), and I am convinced that it is identical with Sewell's Indian form, *Cercariae Indicae* IV. For this reason the new name, *Cercaria philippindica,* is offered, in as much as Sewell's terminology does not constitute a name according to zoölogical nomenclature.

The body is long and narrow, its greatest diameter in front of the acetabulum. It usually presents a slight constriction in the region opposite the acetabulum or at a level immediately posterior to that organ. It is covered with small spines and is darkly pigmented due to the presence of numerous cystogenous glands which are widely distributed in the parenchyma (Plate 2, fig. 1). The tail, which is attached to the posterior end of the body, appears, as in the other members of the Megalurous group, vacuolated and is invaginated at the distal end to form a so-called "adhesive organ." The oral and ventral suckers are more or less circular in outline and of about the same size, the ventral sucker being located in the middle, or a trifle behind the middle, of the body length.

The digestive tract is well developed. The mouth, which is subterminal in position, leads through a narrow passage in the oral sucker into a prepharynx, the latter being followed in succession by a pharynx, an œsophagus, and two blind cæca which reach almost to the extreme posterior end of the body.

The measurements of the different organs noted above under various conditions are as follows, based on well-extended specimens: Living specimens, body 0.605 by 0.147 millimeter in size, tail 0.450 by 0.030, oral sucker 0.071 (transverse diameter), acetabulum 0.080 (transverse diameter), prepharynx 0.032 (length), pharynx 0.027 (transverse diameter), œsophagus 0.093 (length); in stained, mounted specimens, body 0.500 by 0.113, tail 0.400 by 0.034, oral sucker 0.052 by 0.046, acetabulum 0.053 by 0.057, prepharynx 0.036, pharynx 0.024, œsophagus 0.090.

The excretory bladder, which opens through a median dorsal pore, is pyriform in shape and gives off the following vessels: Anteriorly, two main lateral collecting tubes which reach to the posterior level of the pharynx, from where they turn back and at the level of the acetabulum each divides into anterior and posterior collecting tubules; posteriorly, a caudal collecting tube which goes into the tail.

I was not able to study the flame-cell formula due to the fact that I encountered this larva at a time of day when it was not possible for me to keep it under prolonged observation. I left the specimens overnight in a dish of water, hoping to study them again; but when morning came they had all perished. Instead, I found a large number of characteristic flask-shaped figures which I immediately took for cysts due to their resem-

blance to those described by Looss (1900). In fact, they were cysts, for inside some of them I was able to observe the inclosed cercariæ still moving. In Plate 2, fig. 5, is shown the outline of one of these cysts, which measure 0.34 by 0.20 millimeter in size.

The reproductive system is represented by small cells arranged in the form of a streak which extends from behind the point where the œsophagus divides to immediately in front of the excretory bladder.

Development takes place in rediæ which are provided posteriorly with a pair of locomotor appendages. Measurements taken of living rediæ were: Mature ones packed full with cercariæ 2.07 millimeters by 0.36 millimeter in size; young ones containing no cercariæ 0.50 by 0.08. In young rediæ the pharynx is prominent and the rhabdocœle gut may extend posteriorly almost to the level of the locomotor appendages. I was able to detect four flame cells in such young forms, as shown in Plate 2, fig. 3.

CERCARIA MELANIASPERATA sp. nov. Plate 3, figs. 1, 2, and 3.

Hosts, *Melania* sp. and *M. aspereta philippinensis.*

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentage of infestation, *Melania* sp., 18; *M. asperata philippinensis,* 16, July, 1927.

This small cercaria is referred to Sewell's "Pusilla" group of Xiphidiocercariæ, being similar in many respects to *Cercariae Indicae* XVIII and *C. Indicae* XIX. It is an active swimmer in open water; on a substratum it makes attempts to move by means of its suckers and the general contraction and relaxation of the body, but makes very little progress or none at all.

The body is generally oval in shape, but is capable of considerable elongation and contraction; it measures, when extended, from 0.086 millimeter long by 0.060 millimeter in maximum width to 0.100 by 0.050. In the moderately contracted state it measures on the average 0.078 by 0.056. The tail, which is attached on the ventral aspect of the posterior end of the body, when extended, is 0.108 to 0.130 millimeter long by 0.012 to 0.014 millimeter wide at or near the base. It can, however, be contracted so that it may be shorter than the body. The body surface is covered with minute, posteriorly directed spines, but the tail is unarmed.

The oral sucker is moderately developed, from 0.024 by 0.026 millimeter to 0.030 by 0.030 in size. Its anterior dorsal wall carries a stylet of the shape shown in Plate 3, fig. 2, measuring 0.020 to 0.024 millimeter in length by 0.002 in maximum width. The acetabulum, averaging about 0.015 millimeter in transverse diameter, is situated immediately behind the middle of the body length. The mouth is subterminal in position and leads through a cavity of the oral sucker into a small pharynx, about 0.005 millimeter in transverse diameter and found immediately behind the oral sucker. Three pairs of conspicuous salivary glands are found lateral to the acetabulum, the first pair being a little anterior, the second pair opposite, and the last pair posterior, of the middle level of that organ. The glands are finely granular, the first two pairs appearing lighter and the third pair greenish in color. Their ducts pass dorsally to the oral sucker to open at both sides of the stylet.

The excretory bladder, which opens outside through a median dorsal pore, is reniform in shape. From each horn of the bladder a main lateral collecting tube arises, which at about the level of the acetabulum divides into an anterior and a posterior collecting tubule. The anterior collecting tubule, after giving off a short branch near its point of origin, courses anteriorly toward the lateral aspect of the oral sucker where it divides into two branches. The ramifications of the posterior collecting tubule are the counterparts of those of the anterior collecting tubule; that is, after sending off a branch from near its point of origin, it goes posteriorly toward the lateral aspect of the excretory bladder, where it divides into two branches. Each of the branches of the collecting tubules ends in a flame cell so that the total number of these excretory cells on one side of the body is six. The excretory formula is, therefore, $2 \times 6 \times 1 = 12$ flame cells in all. A caudal excretory tube going into the tail is given off from the posterior diverticulum of the excretory bladder.

The reproductive system is represented by an elongated mass of small round cells, occupying a median longitudinal position in the middle third of the body length.

The development of this cercaria occurs in simple elongated sporocysts, which vary in size from 0.34 by 0.06 millimeter to 0.70 by 0.16. The number of cercariæ noted in each sporocyst was from 4 to 34.

CERCARIA MAQUILINGI sp. nov. Plate 3, figs. 4 and 5.

Hosts, *Melania* sp. and *M. asperata philippinensis.*

Location, liver.

Locality, Los Baños, P. I. (Molawin Creek.)

Percentages of infestation, *Melania* sp., 12; *M. asperata philippinensis,* 8, July, 1927.

This cercaria, which belongs to the "Virgula" group of the Xiphidiocercariæ, has practically the same behavior as *Cercaria melaniasperata.* It is however larger, the body when moderately extended measuring about 0.120 millimeter in length by 0.080 in maximum width. Under the same condition the tail, which is attached on the ventral aspect of the posterior end of the body, is about as long as the latter, but it may be so contracted as to appear as a mere stump. The body is covered with small, backward-pointing spines. The entire surface of the tail is similarly armed, although in some specimens only its posterior region appears to carry spines.

The oral sucker, which contains a characteristic structure, the "virgula organ" of Sewell (1922), is slightly oval or circular in outline, having an average diameter of 0.04 millimeter. The stylet is 0.018 to 0.020 millimeter in length by 0.004 to 0.005 in maximum width and is located anterior to the virgula organ. The circular acetabulum, 0.02 millimeter in diameter, is found behind the middle of the body length. The mouth, which is subterminal in position, leads into a small pharynx, 0.008 millimeter in transverse diameter, located immediately behind the oral sucker. Three pairs of salivary glands are present; the first two pairs are anterior to the middle of, and the last pair at the same level as, the acetabulum. The first and third pairs of salivary glands are coarsely granular and of greenish hue, while the second pair is finely granular and of lighter color. The corresponding ducts of these glands open, as in other cercariæ, at the anterior end, dorsal to the mouth opening.

The structure of the excretory system is quite similar to that of *C. melaniasperata.* The excretory bladder is triradiate, from the posterior horn of which a caudal collecting tube going to the tail is given off. From the anterior horns of the bladder arise the two main lateral collecting tubes, each of which divides at the level of the acetabulum into an anterior and a posterior collecting tubule. Each collecting tubule in turn divides into

three capillary branches, each of which connects with a flame cell. The excretory formula is, therefore, $2 \times 6 \times 1 = 12$ flame cells in all.

The genital mass of small round cells is curved in outline and is situated immediately dorsal to the acetabulum.

Development occurs in small, simple, roundish to oval sporocysts, 0.27 by 0.21 millimeter, containing from 5 to 15 cercariæ in varying stages of development.

CERCARIA LAGUNAENSIS sp. nov. Plate 4, figs. 1 and 2.

Host, *Ampullaria lagunaensis.*

Location, liver.

Locality, Los Baños, P. I. (Laguna de Bay and Maitim Creek.)

Percentage of infestation, 5 to 8, August, 1927.

This cercaria is an active swimmer. The clear transparent body is ovoid in shape and is covered with minute spines. It measures from 0.13 to 0.17 millimeter in length by 0.08 to 0.09 millimeter in maximum width. The tail, which is unarmed and attached on the ventral aspect of the posterior end of the body, is from 0.23 to 0.28 millimeter long by 0.03 millimeter in width near the base.

The oral sucker, 0.04 by 0.03 millimeter to 0.06 by 0.05 in size, is provided with a stylet, 0.048 to 0.060 long, which appears to be inclosed within a membranous capsule. The acetabulum, 0.03 millimeter in diameter, is weak and poorly developed, and is located in the anterior region of the second third of the body length. The mouth is subterminal in position. Immediately behind the oral sucker is a pharynx, 0.008 millimeter in transverse diameter, followed by a blind œsophagus. There are three pairs of pyriform salivary glands, lying on each side of the acetabulum. The first two pairs of these glands are finely granular and darkish in appearance, while the third pair, which is also finely granular, has a hyaline appearance. The ducts of these glands open at the dorsal lip of the mouth.

The excretory system is composed of a reniform excretory bladder, which opens outside through a median dorsal pore; two main lateral collecting tubes, which divide in the middle of the body length into anterior and posterior collecting tubules; a median, caudal collecting tube which goes to the tail; and 18 pairs of flame cells, as shown in Plate 4, fig. 1. The excretory formula is, therefore, $2 \times 18 \times 1 = 36$ flame cells in all.

The reproductive system is represented by a rounded mass of cells anterior to the acetabulum.

Cercaria lagunaensis develops in simple, round to oval sporocysts, containing from 2 to 10 cercariæ in different stages of development.

CERCARIA RARISSIMA sp. nov. Plate 4, figs. 3 and 4.

Host, *Ampullaria lagunaensis.*

Location, liver.

Locality, Los Baños, P. I. (Irrigation canal at the experiment station of the College of Agriculture, University of the Philippines.)

Percentage of infestation, 1.

This cercaria is very similar in appearance and behavior to *Cercaria lagunaensis,* but I have decided to consider it as a distinct species because of certain differences between the two forms in the appearance and structure of the stylets and salivary glands, both of which organs, according to Sewell (1922), are of specific diagnostic value.

The body of *Cercaria rarissima,* 0.12 to 0.15 millimeter long by 0.08 in maximum width, is covered with minute, backward-pointing spines. The tail, unarmed, is from one and a half to three times as long as the body, on the ventral aspect of the posterior end of which it is attached.

The oral sucker, 0.044 to 0.051 millimeter in transverse diameter, is nearly spherical. The stylet, 0.041 millimeter long, differs from that of *C. lagunaensis* in having thicker walls and a more conspicuous shoulder at the anterior third of its length and it does not appear to be inclosed inside of a membranous capsule. The mouth is subterminal in position; immediately behind the oral sucker is a pharynx, 0.009 millimeter in transverse diameter. The acetabulum, 0.025 to 0.030 millimeter in transverse diameter, is in the anterior portion of the last third of the body length. On each side of the acetabulum are the three pairs of salivary glands, the first two pairs of which are small, pyriform, and finely granular, while the glands of the third pair are larger, irregular in outline, and coarsely granular. The ducts of these glands are very conspicuous, opening on both sides of the dorsal lip of the mouth.

The excretory bladder and principal excretory vessels are arranged as in *C. lagunaensis.* I was able to detect 8 pairs of flame cells, distributed as shown in Plate 4, fig. 3, but it is possible that some cells escaped my detection.

The genital mass is located on a level immediately in front of the acetabulum.

Development takes place in simple, oval sporocysts, containing from 5 to 12 cercariæ in different stages.

CERCARIA MAITIMENSIS sp. nov. Plate 5, figs. 1 and 2.

Host, *Ampullaria lagunaensis*.

Location, liver.

Locality, Los Baños, P. I. (Maitim Creek and Laguna de Bay.)

Percentage of infestation, 10 to 12, August, 1927.

This large cercaria is a clumsy swimmer. It prefers to crawl on the substratum, after the fashion of a measuring worm. In performing the latter movement it uses its two strong suckers, aided by the posterior lateral angles of the body which are sharply defined and the musculature of which appears to be quite well developed.

The body is elongated and covered with prominent spines. It appears pigmented in the region around the acetabulum due to the presence of small dark glands. The tail, unarmed, is attached at the posterior end of the body, between the constricted posterolateral angles of the latter. The oral sucker is well developed and carries a stylet of the shape shown in Plate 5, fig. 2. The acetabulum, like the oral sucker, is circular in outline and well developed, and is situated near the middle of the body length. Behind the oral sucker is a short prepharynx, followed in succession by a small pharynx and a short œsophagus which divides into two cæcal diverticula.

Sizes under various conditions: Maximum extension of living specimens, body 0.37 by 0.14 millimeter, tail 0.38 by 0.033 (near base), prepharynx 0.013 long, pharynx 0.013 in transverse diameter, œsophagus 0.020 long, oral sucker 0.060 in transverse diameter, acetabulum 0.060 in transverse diameter, stylet 0.035 by 0.006 (at base); well-extended, mounted, stained specimens, body 0.340 by 0.080, tail 0.210 by 0.022, oral sucker 0.04, acetabulum 0.04, prepharynx 0.008, pharynx 0.012, œsophagus 0.008.

There are three pairs of brownish, very finely granular, pyriform salivary glands at the posterior end of the body, on each side of the excretory bladder. They are individually distinct when the body is well extended, but when the body is contracted their nuclei become hidden and they seem to coalesce, forming a hat-shaped figure which totally obscures the outline of the ex-

cretory bladder. The ducts of these glands are very prominent and open on both sides of the dorsal lip of the mouth.

The excretory system is composed of the following: A flower-vase-shaped excretory bladder which opens outside through a median dorsal pore; two main lateral collecting tubes which arise from the anterolateral angles of the bladder and which divide at a level midway between the bladder and the acetabulum into anterior and posterior collecting tubules; a caudal collecting tube arising from the posterior diverticulum of the bladder and going into the tail; and the fine excretory capillaries which permeate the body substance and which end in 18 pairs of flame cells. The excretory formula is, therefore, 2 x 18 x 1 = 36 flame cells in all.

The genital mass is a C-shaped structure found dorsal to the acetabulum.

This larva develops in simple, sausage-shaped sporocysts, 0.27 to 0.41 millimeter by 0.08 to 0.10 in size, containing from 3 to 12 cercariæ in different stages of development.

CERCARIA DORSOCAUDA sp. nov. Plate 5, figs. 3 and 4.

Host, *Ampullaria lagunaensis.*

Location, reproductive glands.

Locality, Los Baños, P. I. (Maitim Creek and irrigation dam between Los Baños and Bay, Laguna, Luzon.)

Percentage of infestation, 10, August, 1927.

This larva belongs to Sewell's "Vivax" group of furcocercous distome cercariæ. Miller (1926), on the other hand, refers the group to the Monostomata and includes its members among his pharyngeal longifurcate monostome cercariæ.

Cercaria dorsocauda is a very active swimmer, moving through the water with the tail invariably foremost. Periods of active swimming generally alternate with periods of rest, during which time it remains suspended under the surface of the water with the tail uppermost.

The body is generally pyriform, attenuated anteriorly and rounded posteriorly, its greatest diameter in the middle of its length. Its surface is covered with prominent spines. The tail, which is also armed with spines, is attached on the dorsal aspect of the posterior end of the body. Distally it becomes slightly constricted and divides into two long rami, which are provided with dorsal and ventral fins throughout their lengths. The two fins are continuous at the tip of each ramus, but they

do not extend appreciably beyond it. Measurements taken of living specimens confined under a cover glass are: Body 0.52 by 0.21 millimeter to 0.64 by 0.40 in size, tail stem 0.56 by 0.07 to 0.65 by 0.04, furci 0.43 to 0.48 by 0.034.

The oral sucker, 0.066 by 0.100 millimeter to 0.093 by 0.107 in size, is a definite organ in this larva, while the acetabulum, 0.033 by 0.040, is rudimentary, and is represented by a roundish mass of parenchymatous cells in the middle of the body length or a little posterior of that level. Immediately behind the oral sucker is a small circular pharynx, 0.034 millimeter in transverse diameter, followed by an œsophagus, 0.08 millimeter in length, which divides into two wide cæca that reach to near the posterior end of the body.

The excretory system is typical of the group. The excretory bladder is more or less pentagonal in shape, opening through a median dorsal pore. From its anterolateral angles are given off the two main lateral collecting tubes, which course anteriorly lateral to the intestines up to the level of the œsophagus. From the anterior angles of the pentagon the median collecting tubes arise, the two uniting behind the acetabulum in a common canal which, behind the cæcal bifurcation, in turn divides into two branches, each branch crossing the corresponding intestine to join at the posterior level of the œsophagus the main lateral collecting tube on that side. Each common vessel thus formed immediately divides into two branches which are usually filled with fatlike globules of excretory material. From the posterior angle of the excretory bladder arises the caudal collecting tube going into the tail, at the distal extremity of the stem of which it divides into branches, each branch going into, and opening at the tip of, the corresponding ramus of the tail. The finer excretory capillaries are difficult to detect, but the flame cells are unusually large and conspicuous. There are 12 pairs of flame cells in the body and 3 pairs in the tail, so that the excretory formula is $2 \times 12 \ (+ 3) \times 1 = 30$ flame cells in all. All the flame cells on one side of the tail are connected to a common capillary tube which empties into the excretory bladder lateral to the point of origin of the caudal collecting tube.

The genital system is represented by a mass of rounded cells situated behind the acetabulum.

This larva develops in long, sausagelike sporocysts, 10 to 15 millimeters long by 0.24 wide.

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ILLUSTRATIONS

ABBREVIATIONS

ac, acetabulum.
at, anterior collecting tubule.
c, collar.
cg, cystogenous gland.
cs, adhesive organ.
ct, caudal collecting tube.
df, dorsal fin.
eb, excretory bladder.
encer, encysted cercaria.
ep, excretory pore.
es, eyespot.
fc, flame cell.
ft, locomotor appendage.
gm, genital mass.
ic, intestine.
lf, lateral fin.
mo, mouth.
mt, main lateral collecting tube.
oes, œsophagus.
os, oral sucker.
ph, pharynx.
pph, prepharynx.
pt, posterior collecting tubule.
rd, rhabdocœle gut.
sd, salivary duct.
sg, salivary gland.
st, stylet.
vf, ventral fin.
vo, virgula organ.

Plate 1

Fig. 1. *Cercaria parvomelaniae* sp nov., dorsal view.
2. *Cercaria parvomelaniae* sp. nov., immature redia.
3. *Cercaria redicystica* sp. nov., ventral view.
4. *Cercaria redicystica* sp. nov., immature redia.
5. *Cercaria redicystica* sp. nov., mature redia.

Plate 2

Fig. 1. *Cercaria philippindica* nom. nov., ventral view, showing cystogenous glands.
2. *Cercaria philippindica* nom. nov., ventral view, showing excretory system and digestive tract.
3. *Cercaria philippindica* nom. nov., immature redia.
4. *Cercaria philippindica* nom. nov., mature redia.
5. *Cercaria philippindica* nom. nov., outline of cyst.

Plate 3

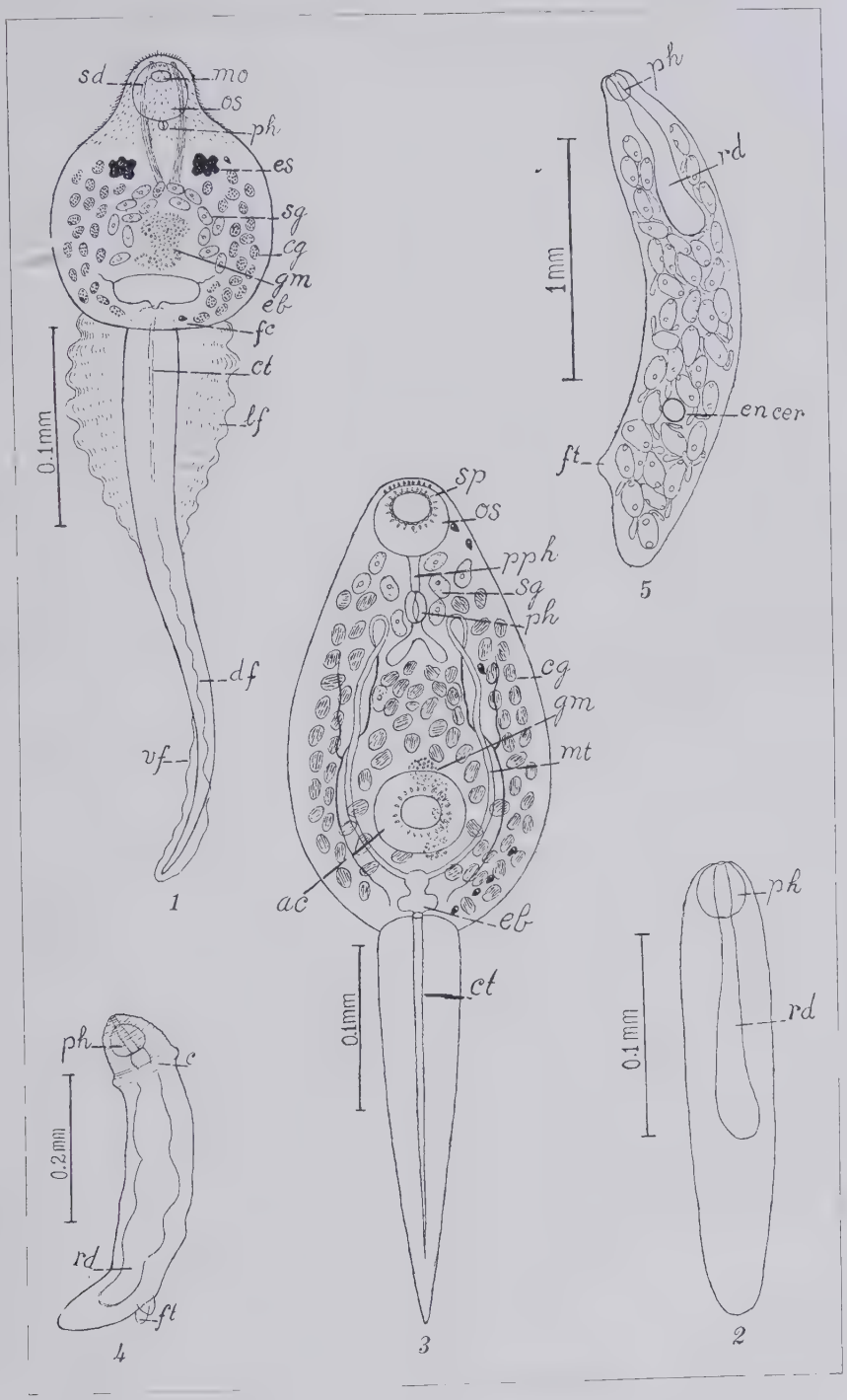
Fig. 1. *Cercaria melaniasperata* sp. nov., ventral view.
2. *Cercaria melaniasperata* sp. nov., stylet.
3. *Cercaria melaniasperata* sp. nov., sporocyst.
4. *Cercaria maquilingi* sp. nov., ventral view.
5. *Cercaria maquilingi* sp. nov., stylet.

Plate 4

Fig. 1. *Cercaria lagunaensis* sp. nov., ventral view.
2. *Cercaria lagunaensis* sp. nov., stylet.
3. *Cercaria rarissima* sp. nov., ventral view.
4. *Cercaria rarissima* sp. nov., stylet.

PLATE 5

FIG. 1. *Cercaria maitimensis* sp. nov., ventral view.
2. *Cercaria maitimensis* sp. nov., stylet.
3. *Cercaria dorsocauda* sp. nov., ventral view, showing proportions of body, tail stem, and furci of tail.
4. *Cercaria dorsocauda* sp. nov., ventral view, showing the excretory system.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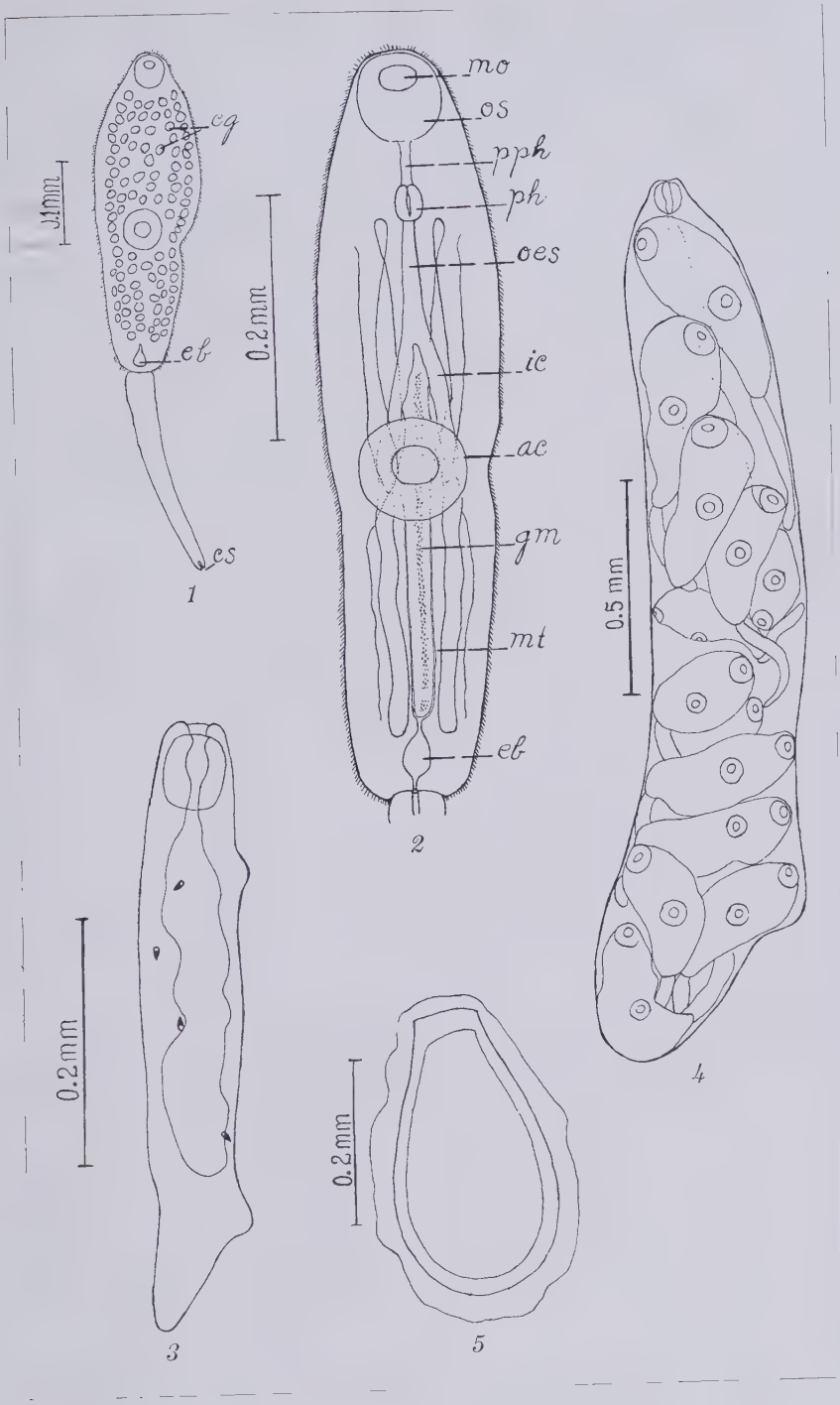
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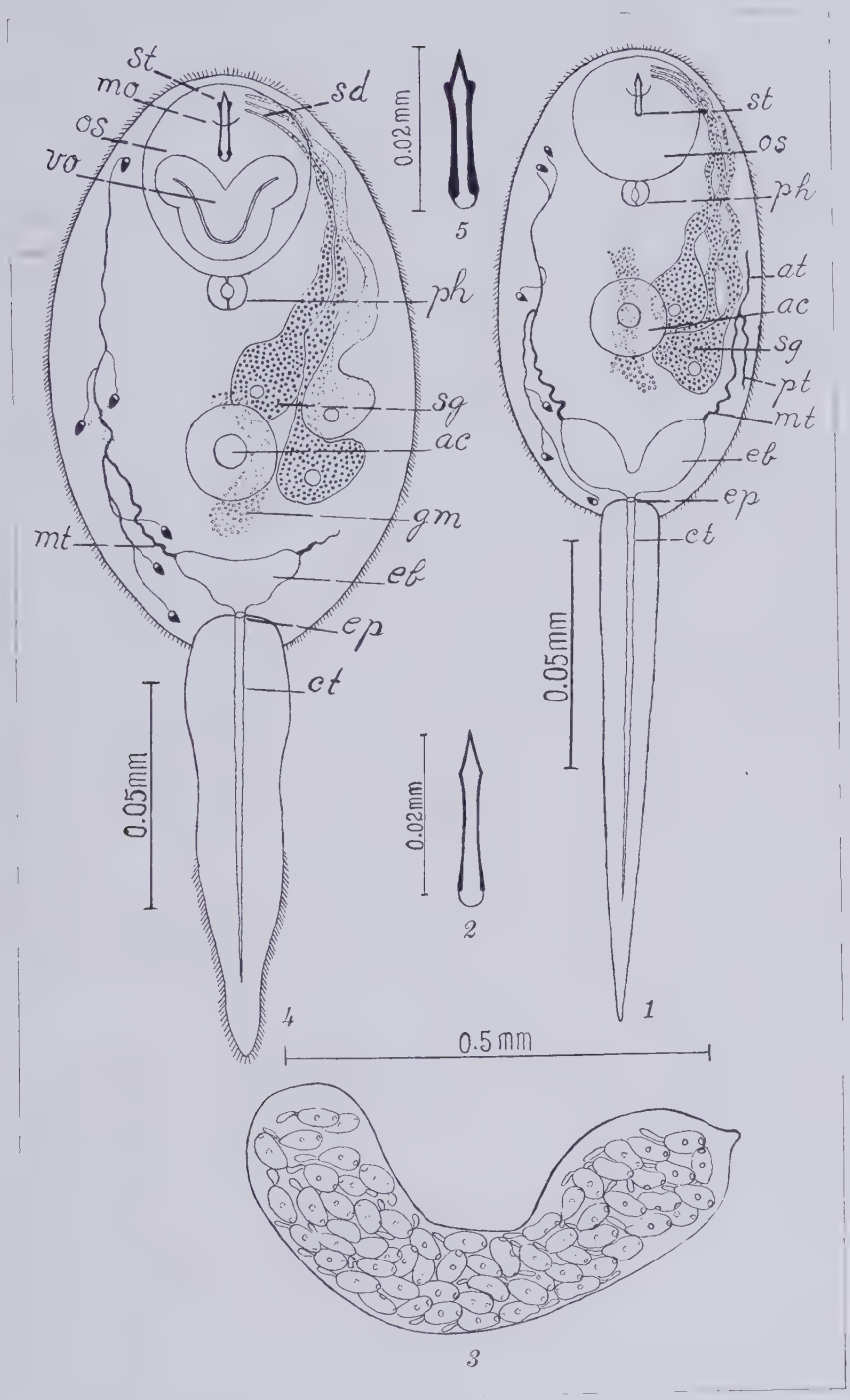
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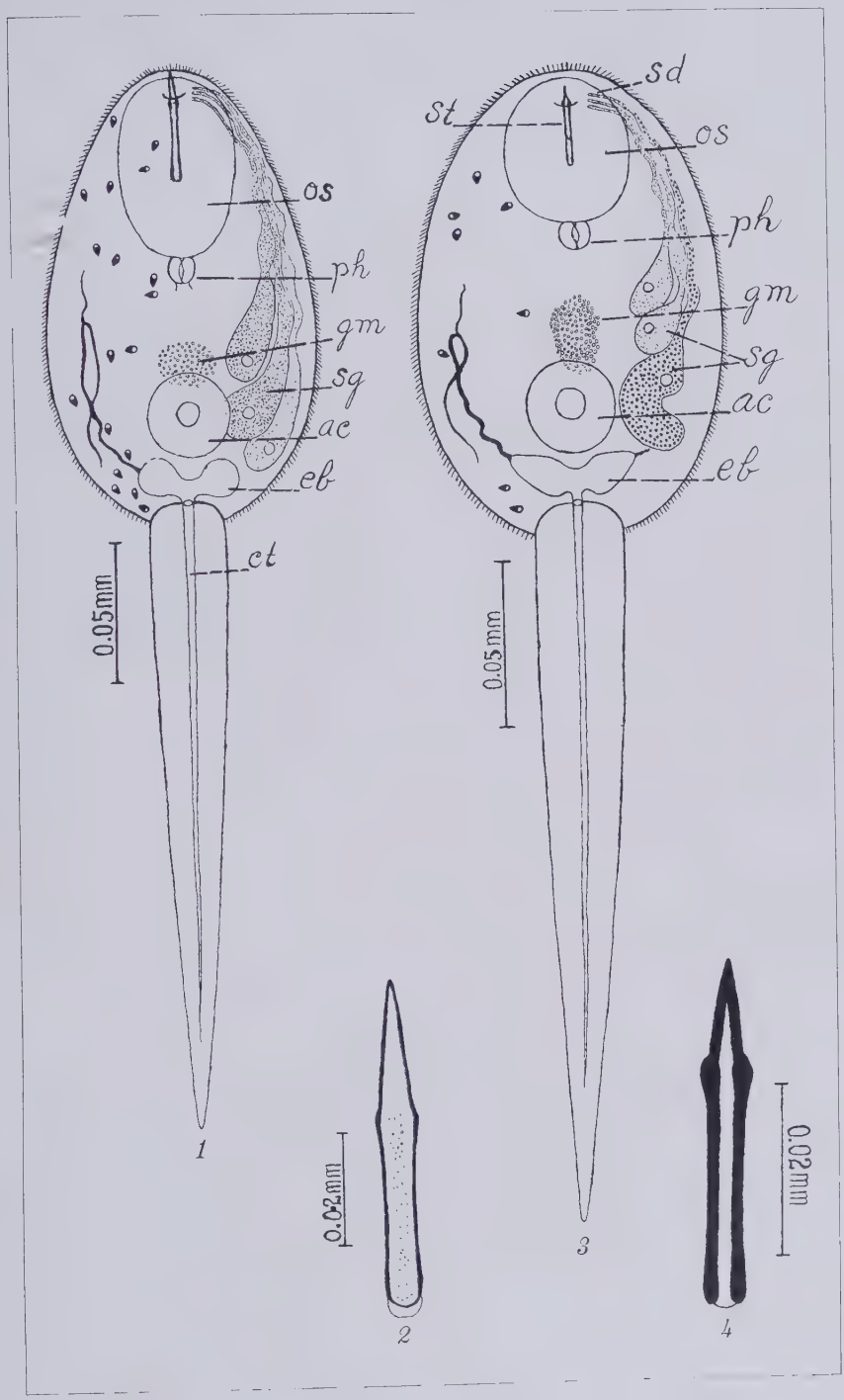
PLATE 3.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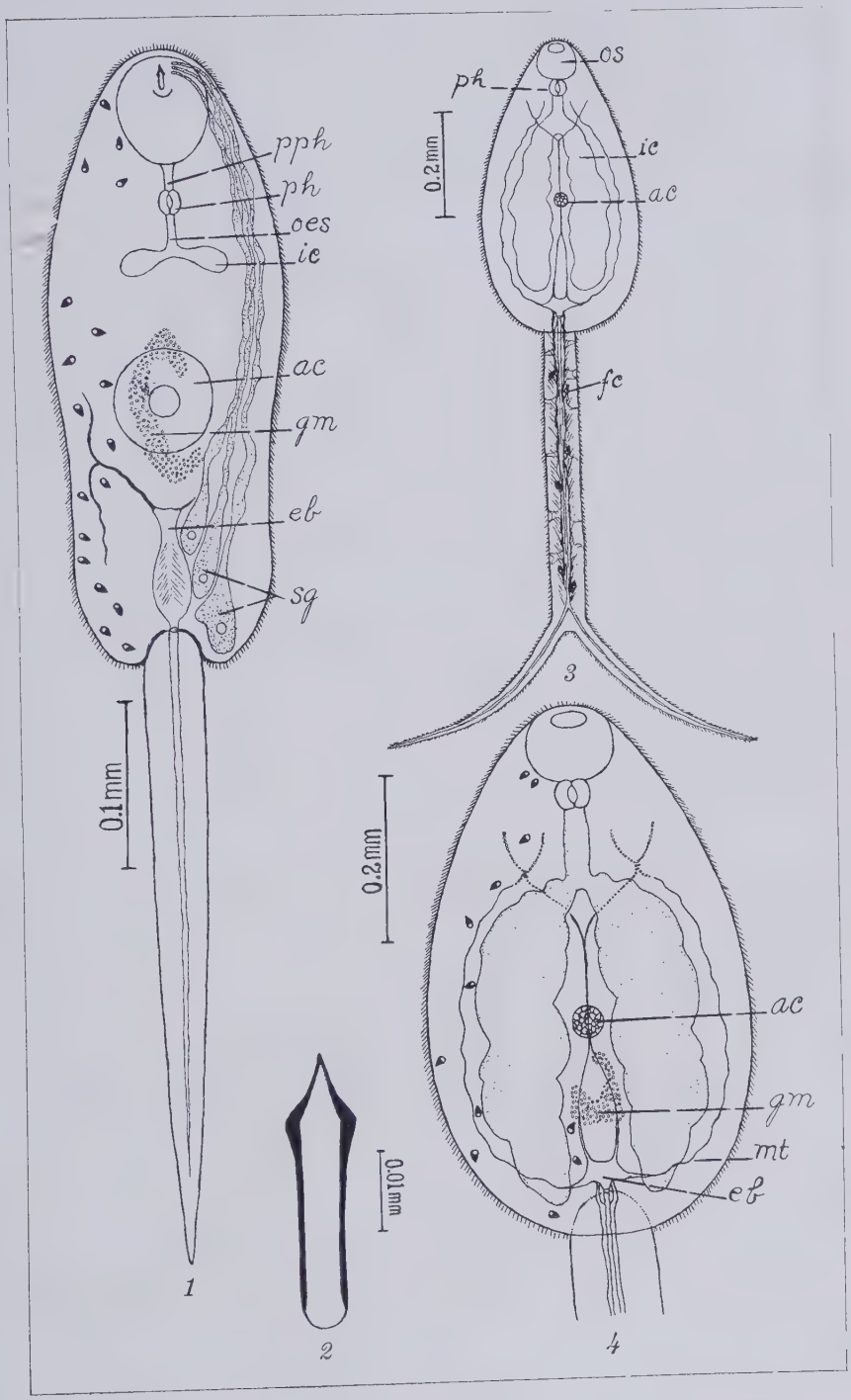
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PLATE 5.

STRENGTH PROPERTIES IN RELATION TO SPECIFIC GRAVITY OF PHILIPPINE WOODS [1]

By José C. Espinosa

Of the Bureau of Science, Manila

FIVE TEXT FIGURES

The strength properties of wood have a certain definite relation with the actual amount of wood material in a given piece or, using the accepted terminology, with its density or specific gravity.

J. A. Newman and T. R. C. Wilson,[2] of the United States Forest Service, have established the relations for American timbers from an analysis of 200,000 tests conducted at the Forest Products Laboratory in Madison, Wisconsin.

L. G. den Berger,[3] writing on the mechanical properties of Dutch East Indian timbers, tabulated these relations, in the case of teak (*Tectona grandis* Linn. f.), not only with its specific gravity but also with the width of the annual rings.

From a study of data covering about 45,000 tests, these relations in the case of Philippine woods have been found and it is the object of this paper to express the above-mentioned relations in simple forms in order that, the specific gravity of a species being known, the corresponding strength values can be readily calculated. Consequently, it is possible to compare the different species as regards strength, and determine which species are especially adapted for certain purposes.

In the treatment of the material at hand, simplicity and clearness have been kept in mind, and the relationships are herewith presented both in graphical and in equation form.

SPECIFIC GRAVITY

As used in timber testing specific gravity is the ratio of the oven-dry weight of a piece of wood to the weight of a volume

[1] Submitted for publication August 20, 1927.

[2] Bull. U. S. Dept. Agr. Forest Service 676.

[3] Korte Mededeelingen van het Proefstation voor het Boschwezen No. 12, Departement van Landbouw, nijverheid en handel in Nederlandsch-Indie.

of water at 4° C. equal to the volume of the specimen at the time of test. Thus, this value is based on the weight of the specimen when oven dry and the volume at the time of test. Obviously, this is not the true specific gravity; but, for purposes of comparison, it has been adopted by standard laboratories on timber tests.

MOISTURE PERCENTAGE

The specimens included in this study are air dry. It has been found that variations in moisture percentage of green timbers have no effect on strength. On the other hand, in the case of air-dry specimens an increase in moisture percentage means a material decrease in strength.

For accurate comparisons between species, all of the strength values have been adjusted to 12 per cent moisture. This adjustment was made in the following manner: The logarithms of the strength values were plotted against the moisture percentage. It was found that the function approximates a straight line. Graphs were made for all the strength properties and, at 12 per cent moisture, the strength value was read directly. Text fig. 1 shows the method of obtaining the fiber stress at the elastic limit in bending for tangile, *Shorea polysperma* Merrill, Dipte-

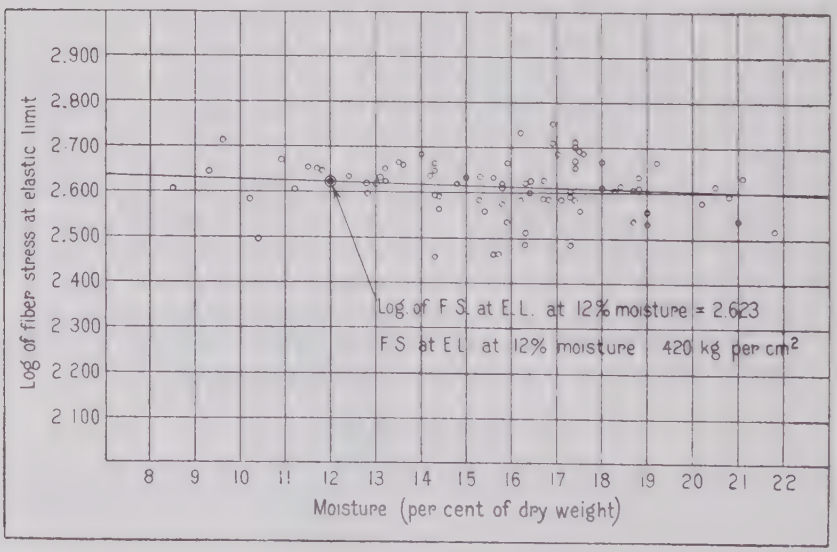

FIG. 1. Fiber stress at elastic limit in bending for tangile, *Shorea polysperma* Merrill, Dipterocarpaceæ. Relation of strength to percentage of moisture. Method of locating the strength at 12 per cent moisture.

rocarpaceæ, at 12 per cent moisture. The moisture content of the air-dry specimen varied from 8 to 22 per cent and, although 18 per cent is about the average in the Philippine Islands, 12 per cent has been chosen in conformity with the percentage given in other publications on timber testing, for purposes of comparison.

THE CURVES AND THEIR CORRESPONDING EQUATIONS

It has been observed, that, if the specific gravity is plotted against a strength property, the points follow either a smooth curve or a straight line which does not pass the origin. Newman and Wilson[4] have found the same behavior in the case of American woods. Following their method of treatment, it was assumed that the curve passes the origin, thereby approximating an equation of the following order:

$$S = kG^s$$

Where

S = the strength value.
k = a constant.
s = another constant.
G = the oven-dry specific gravity

Obviously,

$$\log S = \log k + s \log G.$$

This is the equation of a straight line and, if the logarithms of the strength values are plotted as ordinates, against the logarithms of the specific gravities as abscissas, and the straight line which best averages the points is drawn, the intercept on the Y axis gives k, while the slope of the line gives s.

Text fig. 2 illustrates the method of deriving the equation for longitudinal shear in bending. Each of the points is a species average corresponding to several hundred tests for some species. The straight line that best averages the points gives 59.6 for k and $\frac{5}{4}$ for s.

Thus, the equation for longitudinal shear in bending is:

$S^s = 59.6 \sqrt[4]{G^5}$ in kilograms per square centimeter.

S^s is the longitudinal shear.

G is the oven-dry specific gravity.

This equation is then graphed, using the actual values of ten points from the best average line, mentioned above, and a smooth curve is drawn starting from the origin. This is curve No. 4,

[4] Bull. U. S. Dept. Agr. Forest Service 676.

fig. 3. It can be noticed that, at specific gravities 0.44 and 0.91, two short lines cut the curve. These give the limits of the extent in which this particular curve has been investigated. Dotted lines cover the rest of the curve where no data were available.

The curves in figs. 3, 4, and 5 were prepared in the same manner as outlined above, and give directly in graphical form

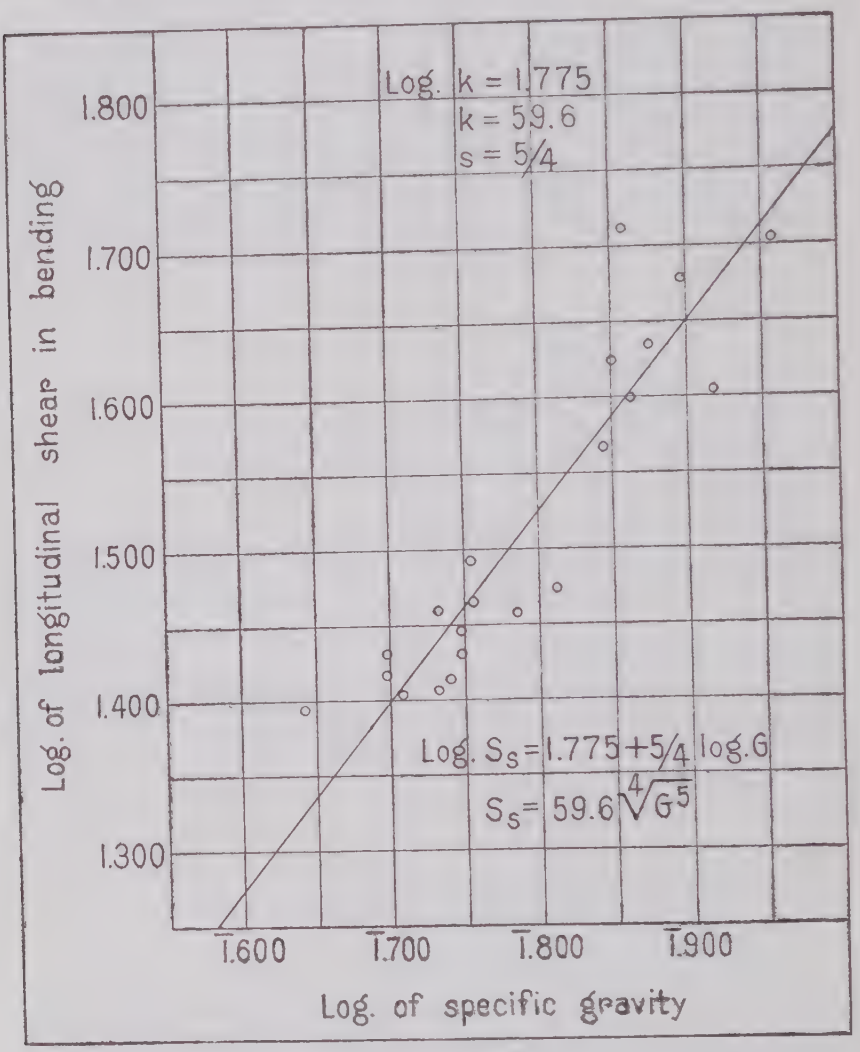

FIG. 2. Longitudinal shear at bending. Method of deriving the equation.

the relations between the strength properties and the specific gravity.

COMPARISON OF EQUATIONS DERIVED FOR AMERICAN WOODS, DUTCH EAST INDIAN WOODS, AND PHILIPPINE WOODS

In Table 1 are tabulated in metric units the equations of strength-specific gravity relations for American woods, Dutch East Indian woods, and Philippine woods.

TABLE 1.—*Equations of specific gravity-strength relation of wood, air dry.*

Strength property.	For Philippine wood, as included in this investigation.	For Dutch East Indian wood, by L. G. den Berger.	For American wood by J. A. Newman and T. R. C. Wilson.
Static bending:			
Fiber stress at elastic limit	$944\sqrt[4]{G^5}$	$700\,G$	$1330\sqrt[4]{G^5}$
Modulus of rupture	$1660\sqrt[4]{G^5}$	$1{,}235\,G$	$1340\sqrt[4]{G^5}$
Modulus of elasticity	$223{,}000\,G$	$172{,}000\,G$	$210{,}000\,G$
Longitudinal shear	$59.6\sqrt[4]{G^5}$		
Work to elastic limit	$0.29\,G^2$		$0.63\,G^2$
Work to maximum load	$2.3\,G^2$		$274\,G^2$
Compression parallel to the grain:			
Crushing strength at elastic limit	$626\sqrt[4]{G^5}$	$405\,G$	$775\sqrt[4]{G^5}$
Maximum crushing strength	$893\sqrt{G^3}$	$705\,G$	$845\,G$.
Compression perpendicular to the grain:			
Crushing strength at elastic limit	$214\,G^2$		$366\sqrt[4]{G^9}$
Shearing strength parallel to the grain	$169\,G$	$120\,G$ radial $140\,G$ tangential.	$255\sqrt[3]{G^4}$ radial $282\sqrt[3]{G^4}$ tangential
Hardness:			
End hardness	$1450\,G^2$	$965\sqrt{G^3}$	$338\sqrt[4]{G^9}$ end
			$253\sqrt[4]{G^9}$ radial
Side hardness	$1410\sqrt{G^5}$		$267\sqrt[4]{G^9}$ tangential

Newman and Wilson [5] said:

By analysis of over 200,000 tests, the Forest Products Laboratory, conducted in coöperation with the University of Wisconsin, Madison, Wis., has now definitely established these relations.

L. G. den Berger [6] said:

[5] Bull. U. S. Dept. Agr. Forest Service 676.

[6] Korte Mededeelingen va het Proefstation voor het Boschwezen No. 12, Department van Landbouw, nijverheid in Nederlandsch-Indie.

The extent of the work done on Philippine woods has already been mentioned. However, it is not out of place to state in this connection that, while numerous tests have already been performed, more tests of other species will be undertaken, because we are aware that further knowledge on the subject may change our figures. These values are the best available at present and are considered reliable for all practical purposes.

TABLE 2.—*Species of wood included in this investigation and their corresponding scientific names.*

Common name.	Scientific name.	Family.
Almon	*Shorea eximia* Scheff	Dipterocarpaceæ.
Amamanit	*Eucalyptus deglupta* Bl	Myrtaceæ.
Apitong	*Dipterocarpus grandiflorus* Blco	Dipterocarpaceæ.
Aranga	*Homalium luzoniense* F. Vill	Flacourtiaceæ.
Bagtikan	*Parashorea plicata* Brand	Dipterocarpaceæ.
Dulitan	*Palaquium merrillii* Dubard	Sapotaceæ.
Guijo	*Shorea guiso* Blco	Dipterocarpaceæ.
Ipil	*Intsia bijuga* O. Ktze	Leguminosæ.
Kalamansanai	*Neonauclea calycina* Merr	Rubiaceæ.
Lumbayao	*Tarrietia javanica* Blco	Sterculiaceæ.
Manggasinoro	*Shorea* sp	Dipterocarpaceæ.
Nato	*Palaquium luzoniense* Vid	Sapotaceæ.
Pahutan	*Mangifera altissima* Blco	Anacardiaceæ.
Palosapis	*Anisoptera thurifera* Bl	Dipterocarpaceæ.
Pototan	*Bruguiera* sp	Rhizophoraceæ.
Red lauan	*Shorea negrosensis* Foxw	Dipterocarpaceæ.
Supa	*Sindora supa* Merr	Do.
Tangile	*Shorea polysperma* Merr	Do.
Tindalo	*Pahudia rhomboidea* Prain	Leguminosæ.
White lauan	*Pentacme contorta* Merr	Dipterocarpaceæ.
Yakal	*Hopea basilanica* Foxw	Do.

I wish to state here clearly that the available data are insufficient in number for this purpose and that the results we have in this respect cannot be more than preliminary.

A general comparison of the equation for American, Dutch East Indian, and Philippine woods shows that, for woods of the same specific gravity, American woods give the highest strength value, Philippine woods give the next highest, and Dutch East Indian woods give the lowest. Exception is made for modulus of elasticity in bending and in end and side hardness, in which Philippine woods excel.

Luis J. Reyes, wood technologist of the Philippine Bureau of Forestry, is here quoted as saying that a possible explanation of the above-mentioned findings is that, in general, the fibers of Philippine woods are shorter than those of American woods.

Then, again, Philippine woods are as a general rule cross-grained, a condition which greatly reduces their strength. Obviously these explanations are at best relative, because it is impossible for anybody to give an accurate and satisfactory explanation of what actually occurs even in simple bending of a piece of wood.

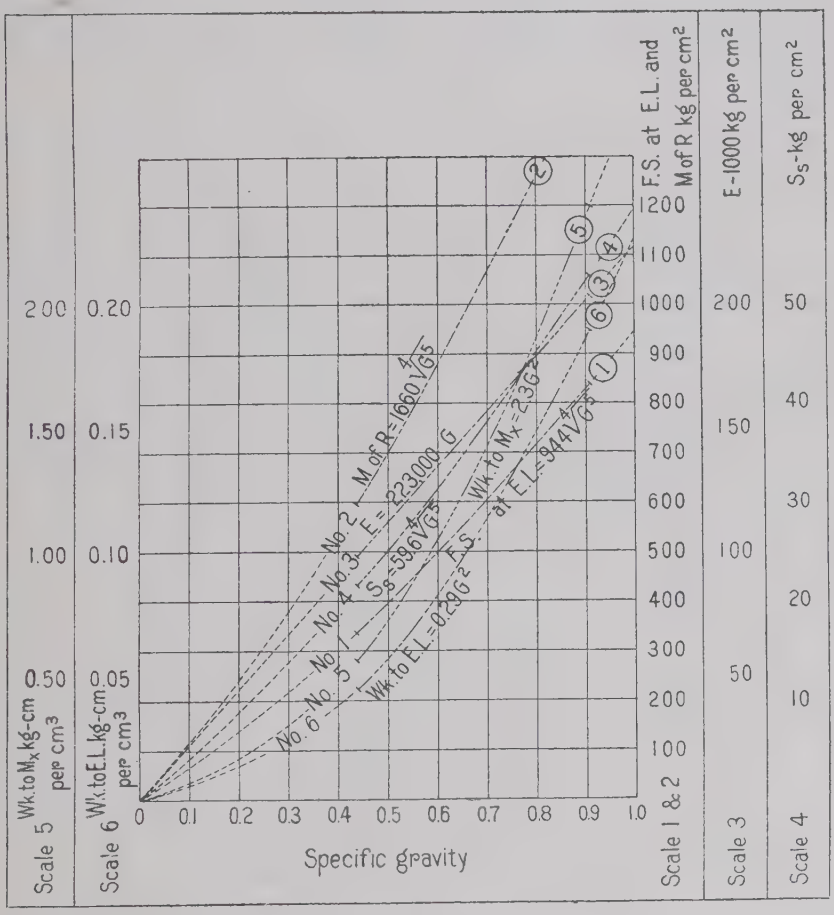

FIG. 3. Static bending; relation of strength properties to specific gravity.

NOMENCLATURE

Scale 1: F. S. at E. L. = fiber stress at elastic limit. Use curve 1.
Scale 2: M of R = modulus of rupture. Use curve 2 (same scale as curve 1).
Scale 3: E = modulus of elasticity. Use curve 3.
Scale 4: S_s = longitudinal shear. Use curve 4.
Scale 5: Wk. to M_x = work to maximum load. Use curve 5.
Scale 6: Wk. to E. L. = work to elastic limit. Use curve 6.

DISCUSSION OF TABLE 3

For clearness Table 3 has been divided into three parts, indicated by Roman numerals.

Part I gives the algebraic relations between the strength properties and the specific gravity.

Part II expresses the measure of accuracy of the equations, in percentages. As can be seen, the limits are fairly close and, for all practical purposes, the equation values are sufficiently accurate.

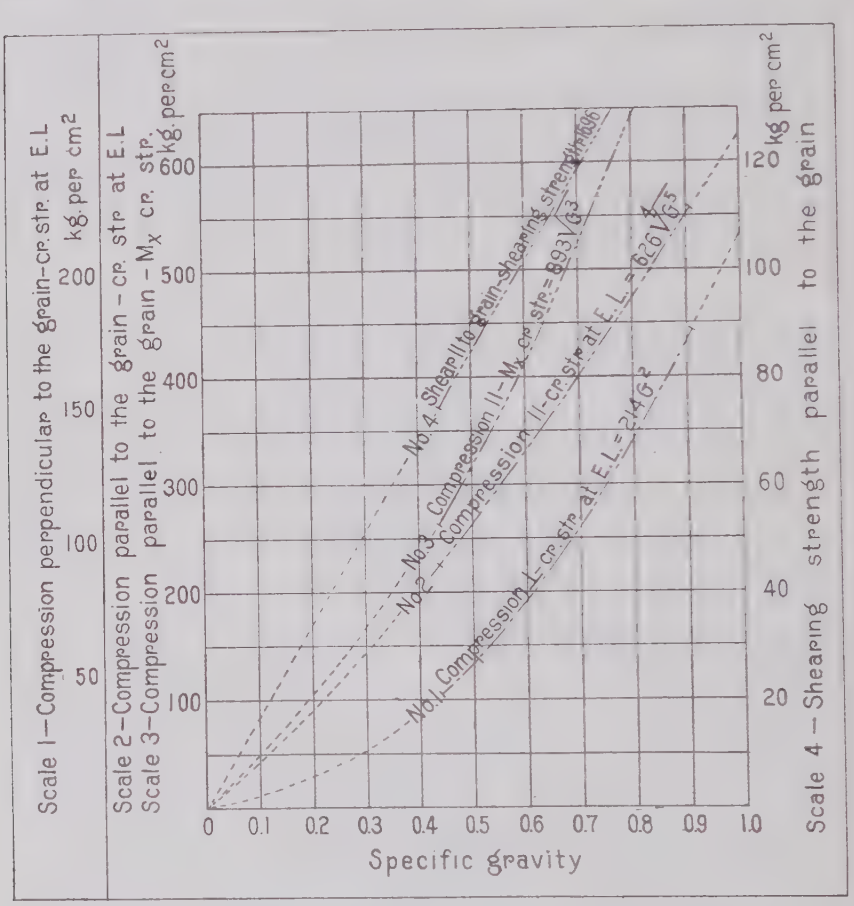

FIG. 4. Relation of strength properties in compression and shear to specific gravity.

GUIDE TO USE OF CURVES

Scale 1: Compression perpendicular to crushing strength at elastic limit. Use curve 1.
Scale 2: Compression parallel to crushing strength at elastic limit. Use curve 2.
Scale 3: Compression parallel to maximum crushing strength. Use curve 3.
Scale 4: Shearing strength parallel to the grain. Use curve 4.

Part III gives the comparison between the equation values and the experimental values. In one instance it can be pointed out that the variation is 202 per cent, as in work to maximum load for almon. This is to be expected, from the fact that wood is

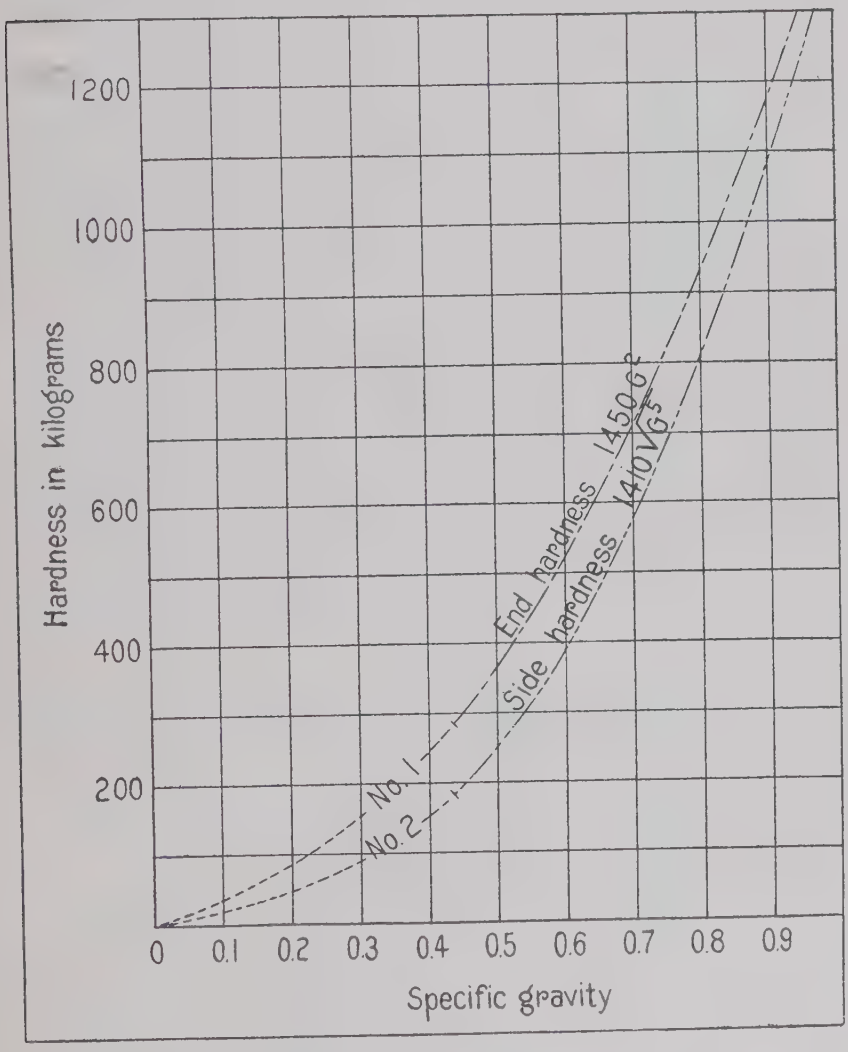

FIG. 5. Relation of end and side hardness to specific gravity.

EXPLANATORY NOTE

End hardness = load required to embed a 1.12-centimeter ball (7/16-inch diameter) one-half its diameter on an end surface. Use curve 1.

Side hardness = load required to embed a 1.12-centimeter ball (7/16-inch diameter) one-half its diameter on a side surface. Use curve 2.

TABLE 3.—*Relation of strength properties to specific gravity.*

[The equations are based on tests of standard clear specimens. The calculations are adjusted to 12 per cent moisture.]

	Static bending.							Compression parallel.					
	Specific gravity, oven dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity, 1,000 kg cm²	Longitudinal shear.	Work to elastic limit.	Work to maximum load.	Crushing strength at elastic limit.	Maximum crushing strength.	Compression perpendicular crushing strength at elastic limit.	Shear parallel to grain.	Hardness, end.	Hardness, side.
Part I.—Equations.													
Air-dry adjusted to 12 per cent moisture contents.		$944\sqrt[4]{G^5}$ kg per cm²	$1660\sqrt[4]{G^5}$ kg per cm²	$223\ G$ 1000 kg per cm²	$59.6\sqrt[4]{G^5}$ kg per cm²	$0.29\ G^2$ kg-cm per cm³	$2.3\ G^2$ kg-cm per cm²	$626\sqrt[4]{G^5}$ kg per cm²	$893\sqrt{G^3}$ kg per cm²	$214\ G^2$ kg per cm²	$169\ G$ kg per cm²	$1450\ G$ kg	$1410\sqrt{G^3}$ kg
Part II.—Measure of accuracy of respective equations (per cent of equation value).													
10 per cent of number of species are above—		122	116	113	108	150	167	126	126	130	109	120	146
10 per cent of number of species are below—		87	84	85	86	72	66	83	83	80	88	74	94
25 per cent of number of species are above—		113	105	104	104	125	140	109	114	113	103	101	132
25 per cent of number of species are below—		90	95	91	93	93	79	93	92	92	94	86	103
Part III.—Comparison of actual value as obtained by tests with equation value.													
Common name.													
Almon:													
Experimental value	0.50	548	741	124	27.0	0.117	1.17	373	414	59.6	86.7	423	374
Equation value		397	698	112	25.1	0.073	0.575	263	316	53.5	84.5	363	294
Per cent of equation value		138	106	117	107	160	202	142	131	111	103	116	150

Amamanit:														
Experimental value	0.57	530	880	132	31.2	0.124	1.08	332	417	53.7				
Equation value		468	822	127	29.5	0.094	0.75	310	384	69.5				
Per cent of equation value		113	107	104	106	132	140	107	108	77				
Apitong:														
Experimental value	0.61	458	803	141	28.7	0.091	0.857	327	387	64.1	90.2	468	411	
Equation value		509	895	136	32.1	0.108	0.856	337	425	79.6	103	540	410	
Per cent of equation value		90	90	104	89	84	100	97	91	80	87	87	100	
Aranga:														
Experimental value	0.83	661	1,153	157	40.3	0.145	0.813	432	619	151	127	984	817	
Equation value		748	1,315	185	47.2	0.200	1.58	496	675	147	140	999	885	
Per cent of equation value		88	80	85	85	72	51	87	92	103	91	98	92	
Bagtikan:														
Experimental value	0.57	447	813	130	29.2	0.117	0.891	354	400	67.8	89.1	350	339	
Equation value		468	822	127	29.5	0.094	0.747	310	384	69.5	96.3	471	346	
Per cent of equation value		95	99	102	99	125	119	114	104	98	92	75	115	
Dulitan:														
Experimental value	0.54	355	813	102	28.8	0.084	1.12	240	332	48.0				
Equation value		437	768	120	27.6	0.085	0.671	290	354	62.4				
Per cent of equation value		81	106	85	104	99	167	83	94	77				
Guijo:														
Experimental value	0.73	672	1,175	184	39.8	0.155	1.27	437	557	107	118	562	617	
Equation value		637	1,120	163	40.2	0.155	1.23	422	557	114	123	773	642	
Per cent of equation value		105	105	113	99	100	103	104	100	94	88	73	96	
Ipil:														
Experimental value	0.72	1,002	1,452	175	51.5	0.316	1.32	646	741	142		750	929	
Equation value		626	1,101	161	39.5	0.150	1.19	415	546	110		752	620	
Per cent of equation value		160	132	108	130	210	111	156	136	129		100	150	
Kalamansanai:														
Experimental value	0.71	711	1,253	159	42.2	0.215	1.66	442	627	141	132	893	832	
Equation value		615	1,082	158	38.9	0.146	1.16	408	534	108	120	731	599	
Per cent of equation value		116	106	100	108	147	143	108	117	130	110	122	139	

TABLE 3.—*Relation of strength properties to specific gravity*—Continued.

Common name	Static bending.							Compression parallel.					
	Specific gravity, oven dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity, 1,000 kg cm ^{2}	Longitudinal shear.	Work to elastic limit.	Work to maximum load.	Crushing strength at elastic limit.	Maximum crushing strength.	Compression perpendicular crushing strength at elastic limit.	Shear parallel to grain.	Hardness, end.	Hardness, side.
	Part III. Comparison of actual value as obtained by tests with equation value.												
Lumbayao:													
Experimental value	0.56	425	785	111	27.9	0.095	0.724	264	378	61.9	90.5	392	342
Equation value		457	804	125	28.9	0.091	0.720	303	374	67.1	94.6	455	331
Per cent of equation value		93	98	89	97	104	100	87	101	92	96	86	103
Manggasinoro:													
Experimental value	0.44	402	694	111	24.8	0.084	0.750	244	330	48.2	81.0	349	281
Equation value		338	595	98	21.4	0.056	0.445	244	261	41.4	74.4	281	181
Per cent of equation value		119	116	113	116	150	168	109	126	116	109	124	155
Nato:													
Experimental value	0.56	428	821	108	27.0	0.090	0.682	256	336	74.1	90.2	459	431
Equation value		457	804	125	28.9	0.091	0.721	303	374	67.1	94.6	455	331
Per cent of equation value		94	102	86	93	99	95	85	90	110	95	101	131
Pahutan:													
Experimental value	0.65	489	813	132	29.8	0.086	0.643	372	468	83.2	115	603	560
Equation value		551	969	145	34.8	0.123	0.972	365	468	90.4	110	613	480
Per cent of equation value		89	84	91	86	70	66	102	100	92	105	98	117
Palosapis:													
Experimental value	0.54	379	732	111	25.6	0.079	0.757	269	342	58.9	94.7	369	373
Equation value		437	768	120	27.6	0.085	0.671	290	354	62.4	91.3	423	302
Per cent of equation value		87	95	92	93	93	113	93	97	94	104	87	124

Pototan:												
Experimental value	0.75	802	1,365	197	43.2	0.172	0.975	468	581	136	115	977	1,000
Equation value		659	1,159	167	41.6	0.163	1.29	437	580	120	127	816	687
Per cent of equation value		122	118	118	104	105	75	107	100	113	91	120	146
Red lauan:													
Experimental value	0.51	437	724	118	25.2	0.094	0.813	317	365	57.5	81.4	301	313
Equation value		407	715	114	25.7	0.075	0.598	270	324	55.7	86.2	377	262
Per cent of equation value		107	101	103	98	125	136	117	113	103	94	80	119
Supa:													
Experimental value	0.70	597	1,050	126	37.0	0.149	0.887	468	589	162	123	767	762
Equation value		604	1,063	156	38.2	0.142	1.13	401	523	105	118	711	578
Per cent of equation value		99	99	81	97	105	79	117	112	154	114	108	132
Tangile:													
Experimental value	0.55	420	735	116	25.9	0.086	0.698	284	303	55.0	81.3	309	297
Equation value		447	786	123	28.2	0.088	0.696	296	364	64.7	92.9	439	316
Per cent of equation value		94	93	94	92	98	100	96	83	85	88	70	94
Tindalo:													
Experimental value	0.79	716	1,272	130	47.9	0.216	1.37	462	716	193	-------	1,122	1,054
Equation value		703	1,236	176	44.4	0.181	1.44	466	627	134	-------	905	782
Per cent of equation value		102	103	74	108	119	95	99	114	144	-------	124	135
White lauan:													
Experimental value	0.50	426	743	121	26.1	0.085	0.908	331	365	53.0	84.0	357	325
Equation value		397	698	112	25.1	0.073	0.575	263	316	53.5	84.5	363	249
Per cent of equation value		107	106	108	104	116	158	126	115	99	99	98	130
Yakal:													
Experimental value	0.91	800	1,426	209	50.7	0.188	1.35	450	634	147	132	891	937
Equation value		839	1,475	203	53.0	0.240	1.90	556	775	177	154	1,201	1,114
Per cent of equation value		95	97	103	96	90	71	81	82	83	86	74	84

so unhomogeneous, and for this reason the builder must determine the proper factor of safety for his particular construction.

USE OF THE EQUATIONS

No attempt is herein made to place within the limits of physical laws so nonhomogeneous a material as wood. There are so many factors involved, even in simple compression, that, in many instances, the values as found by actual test do not fall within 10 per cent of the equation values. This, however, need not to be regretted, because it is particularly by means of these deviations of the experimental values from the equation values that certain physical characteristics inherent in some species are explained.

A concrete example of the practical use of the equation is the following: Suppose it is desired to know the stiffness in bending of gisok, *Shorea balangeran* Dyer, Dipterocarpaceæ. Gisok is very similar to yakal, *Hopea basilanica* Foxworthy, Dipterocarpaceæ, and is known as such in the market. The oven-dry specific gravity of a certain specimen of gisok is found by experiment to be 0.80; the best measure or stiffness in bending is the modulus of elasticity; and the corresponding equation is 223,000 G, where G is the oven-dry specific gravity. Solving this equation for the specific gravity of 0.80, the modulus of elasticity in bending is 178,000 kilograms per square centimeter. It is seen from Table 3 that the experimental value for this particular strength property, in the case of yakal, is 103 per cent of the equation value. It is therefore reasonable to believe that the same would hold true with gisok, and the value sought is 103 per cent of 178,000, or 183,000 kilograms per square centimeter.

A simpler way of obtaining the value is by using the graph for modulus of elasticity in static bending. Here it is only necessary to strike off, for the specific gravity in question, the corresponding strength value, and to multiply the figure obtained by the correction factor to give the most probable value sought. In like manner the other strength figures can be found either graphically or by the use of the equations.

It is emphasized that no absolute accuracy is claimed for the figures obtained, following the methods herein presented, when innumerable factors are involved in the determination of the strength of wood. It is, however, true that these simple methods

give a certain degree of precision, which is sufficient for all rough predictions of the properties of new species by simply determining the oven-dry specific gravity of the specimen. It is certain that the only reliable figures are those obtained from actual tests on the species; but to obtain these obviously requires a greater amount of time and expense than the purpose would justify, in as much as a large number of tests must be made in order to obtain reliable values.

ILLUSTRATIONS

TEXT FIGURES

ESTERS OF ALPHA LINOLENIC ACID HEXABROMIDE (ISOBUTYL, AMYL, N-PROPYL, AND ISOPROPYL) FROM PHILIPPINE LUMBANG OIL

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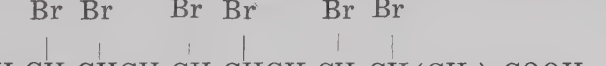
Linolenic and linolic glycerides are the important constituents of vegetable drying oils, since these are the particular substances that absorb oxygen from the air and cause the oil to dry.[1] Linolenic glyceride[2] has a greater capacity for the absorption of oxygen than has any of the other compounds contained in drying oils. This glyceride and the corresponding free linolenic acid are, therefore, substances of considerable importance. Although linolenic glyceride and the free linolenic acid are substances which oxidize readily, they may be separated from an oil in the form of a stable crystallized hexabromide.[3]



Alpha linolenic acid hexabromide

When this crystallized hexabromide is reduced with zinc a molecular rearrangement seems to occur and two linolenic acids are obtained; namely, alpha and beta. Bromination of these mixed linolenic acids gives the crystallized alpha linolenic hexabromide and the liquid beta linolenic hexabromide.[4]

[1] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1922) 42.

[2] West, A. P., and A. I. de Leon, Philip. Journ. Sci. 24 (1924) 123.

[3] Lewkowitsch, J., op. cit. 1 (1921) 212.

[4] Smith, F. L., and A. P. West, Philip. Journ. Sci. 32 (1927) 297. Erdmann, E., and F. Bedford, Ber. Deut. Chem. Gesell. 42 (1909) 1828.

Only very few derivatives of crystallized alpha linolenic hexabromide have ever been prepared. Erdmann and Bedford [5] prepared the potassium and barium salts of the hexabromide and also the methyl and ethyl esters. Imperial and West [6] prepared the barium, zinc, and lead salts and determined the melting point and the solubility of these salts in various solvents. The calcium, magnesium, strontium, and nickel salts have also been prepared.[7]

Since very few derivatives of alpha linolenic hexabromide have been made, it would seem desirable to make a few more derivatives of this substance in order to learn more of the chemistry of these important linolenic compounds.

In this investigation four new esters of alpha linolenic hexabromide were prepared; namely, isobutyl, amyl, *n*-propyl, and isopropyl. The melting point and the solubility of each of these esters in various solvents were determined.

EXPERIMENTAL PROCEDURE

Alpha linolenic hexabromide.—Philippine lumbang oil was used as the material for preparing a supply of alpha linolenic hexabromide. Lumbang oil [8] is obtained from the seeds of *Aleurites moluccana*. It consists almost entirely of glycerides of unsaturated acids; namely, linolenic, linolic, and oleic.[9] It is a drying oil and is used in making paints, varnishes, and similar products.[10] The lumbang oil was pressed from seeds of good quality and filtered first through glass wool and then through filter paper.

Alpha linolenic hexabromide was prepared from lumbang oil in accordance with the procedure adopted by Santiago and West [11] in a recent investigation of lumbang compounds. The lumbang oil was saponified with aldehyde-free alcoholic potassium hydroxide.[12] The mixed potassium salts thus obtained were converted into the mixed acids. The mixed acids were

[5] Ber. Deutsche Chem. Gesell. 42 (1909) 1330.
[6] Philip. Journ. Sci. 31 (1926) 441.
[7] Almoradie, P. R., and A. P. West, Philip. Journ. Sci. 33 (1927) 257.
[8] West, A. P., and W. H. Brown, Bull. P. I. Bur. Forestry 20 (1920) 112.
[9] West, A. P., and Z. Montes, Philip. Journ. Sci. 18 (1921) 619.
[10] West, A. P., and F. L. Smith, Bull. P. I. Bur. Forestry 24 (1923).
[11] Philip. Journ. Sci. 32 (1927) 41.
[12] Dunlap, F. L., Journ. Am. Chem. Soc. 28 (1906) 397.

brominated in ether solution according to the procedure used by Imperial and West [13] in preparing linolenic hexabromide. The ether solution of mixed acids was stirred mechanically by means of a hot-air motor and brominated at —10° C. The insoluble linolenic hexabromide was removed by filtering. After crystallizing several times from ethyl acetate and benzene the melting point of the hexabromide was 179.5 to 180.5° C.

When the mixed acids of lumbang oil are brominated directly no liquid beta linolenic hexabromide is obtained but only the crystallized alpha linolenic hexabromide.

Esters of alpha linolenic hexabromide were prepared by treating the hexabromide with various alcohols in the presence of sulphuric acid.

Isobutyl ester of alpha linolenic hexabromide.—Five grams of alpha linolenic hexabromide were treated with about 600 cubic centimeters of hot isobutyl alcohol. The solution was heated on a boiling water bath and shaken occasionally until most of the hexabromide was dissolved. The solution was then filtered. The clear filtrate was cooled somewhat and treated with 8 cubic centimeters of concentrated sulphuric acid. The mixture of hexabromide, isobutyl alcohol, and sulphuric acid was then heated (reflux) on a wire gauze and allowed to boil gently for about two days. The mixture was then transferred to a distilling flask. The distilling flask containing the mixture was immersed in an oil bath, which was gradually heated to a temperature of about 130° C., and the excess isobutyl alcohol was removed by distilling. When the residue was cooled, the ester crystallized. The ester was then dissolved in ether and the ethereal solution was treated with a concentrated solution of potassium carbonate to neutralize the acid present. The ethereal solution was then separated from the aqueous carbonate solution, washed with water, and dehydrated with anhydrous sodium sulphate. The excess ether was then eliminated by distilling. The residue was crystallized several times from ether and twice from ethyl alcohol. The purified ester was obtained as white crystals which melted at 136 to 138° C. The yield was about 56 per cent.

The ester dissolved readily in the following hot solvents: Xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon bisulphide, and carbon tetrachloride. The ester was also soluble in hot ethyl alcohol

[13] Philip. Journ. Sci. 31 (1926) 441.

and isopropyl alcohol but insoluble in hot methyl alcohol and petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{22}H_{28}Br_6O_2$	58.94
Found	58.79

Amyl ester of alpha linolenic hexabromide.—Seven grams of alpha linolenic hexabromide were treated with about 250 cubic centimeters of hot amyl alcohol. The solution was boiled until most of the hexabromide was dissolved and then filtered. The clear solution was cooled somewhat and treated with 8 cubic centimeters of concentrated sulphuric acid. The mixture was heated (reflux) on a wire gauze and boiled gently for about two days. The excess amyl alcohol was removed by distilling the mixture over an oil bath. When cooled the ester crystallized. The ester was dissolved in ether and the ethereal solution neutralized with potassium carbonate, washed with water, and dehydrated with anhydrous sodium sulphate. The excess ether was then removed by distilling. The residue was crystallized several times from ether and twice from ethyl alcohol. The ester was obtained as white crystals and melted at 133 to 135° C. The yield was about 46 per cent.

Qualitative solubility experiments showed that the ester dissolved readily in hot xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, and carbon tetrachloride. The ester was also soluble in hot ethyl alcohol, isopropyl alcohol, and isobutyl alcohol. It was found to be insoluble in hot methyl alcohol and petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{23}H_{40}Br_6O_2$	57.95
Found	57.47

N-propyl ester of alpha linolenic hexabromide.—Five grams of alpha linolenic hexabromide were boiled with about 600 cubic centimeters of *n*-propyl alcohol. The solution was filtered and treated with 6 cubic centimeters of concentrated sulphuric acid. The mixture was heated (reflux) on a wire gauze and boiled gently for about two days. The excess propyl alcohol was removed by distilling. The residue consisting mostly of the propyl ester crystallized when cooled. The ester was dissolved in ether and purified in the same manner as the isobutyl and

amyl esters. The white crystals of *n*-propyl ester melted at 144 to 146° C. The yield was about 76 per cent.

The ester dissolved readily in hot xylene, toluene, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, and carbon tetrachloride. The ester was also soluble in hot methyl alcohol, ethyl alcohol, *n*-propyl alcohol, isopropyl alcohol, isobutyl alcohol, and amyl alcohol. The ester was only slightly soluble in hot petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{36}Br_6O_2$	59.95
Found	59.36

Isopropyl ester of alpha linolenic hexabromide.—This ester was prepared in the same manner as were the other esters. Five grams of the hexabromide were boiled with about 600 cubic centimeters of isopropyl alcohol. The solution was filtered and treated with about 6 cubic centimeters of concentrated sulphuric acid. The mixture was boiled gently for about two days, after which the excess isopropyl alcohol was removed by distilling. When extracted with ether and the ethereal solution purified, the ester was obtained as white crystals which melted at 141 to 143° C. The yield was about 66 per cent.

The ester dissolved readily in the following hot solvents: Xylene, toluene, petroleum ether, ethyl benzoate, ethyl acetate, acetone, methyl benzoate, benzene, chloroform, carbon disulphide, carbon tetrachloride, methyl alcohol, ethyl alcohol, *n*-propyl alcohol, isopropyl alcohol, isobutyl alcohol, and amyl alcohol.

Analysis:

	Bromine. Per cent.
Calculated for $C_{21}H_{36}Br_6O_2$	59.95
Found	59.38

SUMMARY

Four new compounds, derivatives of crystallized alpha linolenic hexabromide, were prepared from Philippine lumbang oil. These new compounds are the isobutyl, amyl, *n*-propyl, and isopropyl esters of crystallized alpha linolenic hexabromide.

These esters were prepared by the interaction of alpha linolenic hexabromide with various alcohols in the presence of sulphuric acid.

The melting point of these esters was determined and also the solubility in various solvents.

NEW STEPHANIDÆ FROM BORNEO AND THE PHILIPPINE ISLANDS, V

By E. A. Elliott

Fellow of the Zoölogical Society of London and of the Entomological Society of London

Subfamily FOENATOPUS Smith

This appears to be a somewhat widely distributed subfamily, chiefly recorded from the Indo-Australian Region and Africa. The number and the color of the hind femoral teeth furnish a convenient means of dividing the species into well-defined groups, and the sculpture of the head is perhaps the next most important feature.

Key to species of Foenatopus.

FEMALES

11. 1. Hind femora tridentate.
11. 2. Femoral teeth white.
6. 3. Frons arcuate striate.
5. 4. Vertex and occiput rugose punctate; anterior tubercle well developed..... **F. butuanus** sp. nov.
4. 5. Vertex and occiput not punctate; anterior tubercle very small. **F. gracilis** sp. nov.
3. 6. Frons transversely, not arcuately striate.
10. 7. Hind femora transaciculate.
9. 8. Vertex and occiput finely transstriate, superficially punctate. **F. varicolor** sp. nov.
8. 9. Vertex and occiput transrugose, not punctate. **F. aciculatus** sp. nov.
7. 10. Hind femora smooth; vertex and occiput laterally punctate. **F. rufitarsis** sp. nov.
2. 11. Hind femoral teeth concolorous with femora.
13. 12. Occiput sulcate; radius from apical fourth of stigma, distal section twice as long as the proximal..... **F. rubricaput** sp. nov.
12. 13. Occiput not sulcate, radius from near apex of stigma, both sections of the same length..... **F. insularis** sp. nov.
1. 14. Hind femora bidentate.
16. 15. Hind femoral teeth white; head transverse.... **F. transversus** sp. nov.
15. 16. Hind femoral teeth concolorous with femora.
18. 17. Terebra black..... **F. occellatus** Elliott.
17. 18. Terebra white or yellowish banded.
20. 19. Wings milky white; frons, vertex, and occiput arcuate striate, frons also punctate..... **F. lacteipennis** Schletterer.

19. 20. Wings hyaline.
28. 21. Sculpture of frons arcuate
25. 22. Neck normal.
24. 23. Neck coarsely transstriate; petiole longer than rest of abdomen; terebra longer than body..... **F. rufescens** sp. nov.
23. 24. Neck finely transstriate, petiole as long as rest of abdomen; terebra as long as body..... **F. dubius** sp. nov.
22. 25. Neck very elongate.
27. 26. Mesonotum apically smooth, basally obliquely striate, terebra longer than body..... **F. atripes** Kieffer.
26. 27. Mesonotum irregularly rugose throughout; terebra slightly shorter than body..... **F. intermedius** sp. nov.
21. 28. Sculpture of frons not arcuate.
34. 29. Frons transstriate.
31. 30. Vertex and occiput obliquely striate; metapleuræ rugose; terebra longer than body..... **F. longicollis** Cameron.
30. 31. Vertex and occiput finely transtriate; neck elongate.
33. 32. Metapleuræ and median segment coarsely and closely punctate; separated by a sulcus..... **F. mazarredoi** Caballos.
32. 33. Metapleuræ and median segment cribate punctate, confluent. **F. terecollis** sp. nov.
29. 34. Frons otherwise sculptured.
36. 35. Frons indistinctly, subgranulately striate; mesonotum very short; metapleuræ and median segment confluent.... **F. sibuyanus** sp. nov.
35. 36. Frons rugose.
38. 37. Frons coriaceo-rugose; neck finely transrugose; terebra longer than body, white-banded..... **F. indicus** (Westwood).
37. 38. Frons transversely rugose.
40. 39. Neck coarsely transrugose; terebra longer than body, yellow banded. **F. sumbanus** Enderlein.
39. 40. Neck feebly transrugose; terebra only as long as body, white banded..... **F. glabricoxis** sp nov.

MALES

16. 1. Hind femora tridentate.
13. 2. Femoral teeth more or less white.
6. 3. Two basal teeth white.
5. 4. Mesonotum confluently punctate; metapleuræ and median segment coarsely punctate, confluent ..... **F. flavifrons** Elliott.
4. 5. Mesonotum diffusely punctate, metapleuræ coarsely, median segment diffusely punctate, separated by a carina. **F. pictipes** sp. nov.
3. 6. All femoral teeth white.
10. 7. Hind femora transaciculate.
9. 8. Vertex and occiput transrugose; head rufotestaceous, vertex and occiput dark red..... **F. aciculatus** sp. nov.
8. 9. Frons and vertex finely transstriate, superficially punctate; head flavescent..... **F. varicolor** sp. nov.
7. 10. Hind femora smooth.
12. 11. Vertex and occiput punctate; median segment reticulate punctate; head mostly rufotestaceous..... **F. butuanus** sp. nov.

11. 12. Vertex and occiput not punctate; median segment alutaceous, diffusely punctate; head chiefly white..... **F. albiceps** sp. nov.
2. 13. Hind femoral teeth concolorous with femora.
15. 14. Hind coxæ strongly clavate, much longer than femora; metapleuræ and median segment coarsely punctate, confluent.
F. longicoxis sp. nov.
14. 15. Hind coxæ normal; neck elongate, metapleuræ and median segment cribate punctate, separated by an incomplete carina.
F. insularis sp. nov.
1. 16. Hind femora bidentate.
18. 17. Frons coriaceo-rugose; metapleuræ and median segment confluent; head red..... **F. indicus** (Westwood).
17. 18. Frons arcuate striate; metapleuræ and median segment separated by a carina; head mostly black..... **F. dubius** sp. nov.

FOENATOPUS BUTUANUS sp. nov.

Female.—Frons arcuate striate, vertex and occiput with large superficial punctures, centrally more rugose, with fine longitudinal sulcus, occiput basally more or less smooth; ocellus situated at top of ocellar space, almost between the well-developed posterior tubercles; four carinæ on vertex, the posterior ocelli at the ends of the second and third; posterior margin of head strongly bordered. Scape as long as cheeks; second flagellar joint little longer than first, third longer than first and second together. Neck rather long, apically transrugose, basally almost smooth, semiannular short, apically and laterally punctate, basally smooth. Mesonotum rugose punctate, basally smooth, the three impressions distinct. Scutellum centrally smooth, lateral lobes rugose; metapleuræ smooth above, indistinctly sculptured beneath. Metapleuræ and median segment reticulate punctate, separated by a carina. Petiole finely and evenly transstriate, shorter than the smooth remainder of abdomen. Terebra shorter than body, black or rufescent. Hind coxæ transstriate, as long as the smooth tridentate femora; tibiæ no much longer than femora, compresed in basal three-fifths; metatarsi rather more than twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section twice as long as the proximal.

Black; head beneath, frons, cheeks, and temples, ocelar space, and first flagellar joint flavescent, vertex and occiput red to nigrescent, the carinæ paler; neck sometimes rufescent, petiole and abdomen ventrally more or less rufescent; anterior legs rufotestaceous, middle tibiæ and metatarsi basally white; hind legs red, their tarsi paler. Femoral teeth white. Stigma and nervures red-brown.

Length, 9 to 11 millimeters; abdomen, 5 to 6; petiole, 2 to 8; terebra, 8 to 9.

MINDANAO, Butuan (*Baker*).

Male.—Agrees in sculpture with the female, except that the metapleuræ are more smooth above, the petiole is much shorter than rest of abdomen, and the metatarsi about as long as the remaining joints.

Black: head beneath, cheeks, and temples flavescent; face, frons apically, and three longitudinal lines testaceous, the central line extends to and includes the apical tubercle, the others and the carinæ on vertex are red; anterior legs and hind tarsi rufotestaceous.

Length, 11.5 millimeters; abdomen, 7; petiole, 2.5.

MINDANAO, Iligan, Davao (*Baker*).

The hind femora are sometimes lightly transaciculate. In one male the frons is darker, the lines less distinct and a pale spot in the ocellar space.

FOENATOPUS GRACILIS sp. nov.

Female.—Frons finely arcuate striate, vertex and occiput coarsely transstriate, latter basally smooth: posterior margin of head bordered; three carinæ on vertex; anterior tubercle very small, the rest well developed, posterior ones broad. Scape as long as cheeks; antennæ long and slender, normal. Neck apically coarsely, centrally more finely transstriate, basally and semiannular smooth. Mesonotum apically smooth, basally rugose punctate, the impressions subobsolete. Scutellum centrally smooth, lateral lobes punctate; mesopleuræ smooth. Metapleuræ coarsely, median segment reticulately punctate, separated by a carina. Petiole finely transstriate, shorter than rest of abdomen. Terebra shorter than body, rufescent. Hind coxæ cylindrical, finely transstriate; femora transaciculate, tridentate; tibiæ much longer than femora, compressed in basal two-fifths; metatarsi scarcely three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section about twice as long as the proximal.

Rufotestaceous; mesonotum, scutellum, and abdomen from second segment dark rufescent; vertex rufescent, outer orbits flavescent; middle tibiæ basally whitish; hind legs rather darker than the anterior. Stigma and nervures rufescent. Femoral teeth white.

Length, 9.5 millimeters; abdomen, 5.5; petiole, 2.5; terebra, 3.

MINDANAO, Davao (*Baker*).

FOENATOPUS VARICOLOR sp nov.

Female.—Frons and vertex transstriate, occiput rugose punctate, with central smooth line; three carinæ on vertex; posterior margin of head bordered; ocellar space rugose; posterior tubercles obsolete. Scape about as long as cheeks; second flagellar joint short, third rather longer than first and second together. Pronotum transstriate, basally laterally smooth. Mesonotum short, smooth, impressions weak. Scutellum smooth; mesopleuræ large, smooth above, finely punctate beneath. Metapleuræ coarsely punctate, separated by a carina from the cribrate punctate median segment. Petiole finely and evenly transstriate, shorter than the rest of the smooth abdomen. Terebra shorter than body, with yellowish subapical band. Hind coxæ transstriate, about as long as the finely transstriate, tridentate femora; tibiæ longer than femora, compressed to middle; metatarsi not quite three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section about half as long again as the proximal.

Black; head dark red, frons and vertex nigrescent, a pale line under eyes, three or four basal antennal joints rufous; anterior legs rufescent, middle and hind metatarsi yellowish white, the extreme apex red. Femoral teeth white.

Length, 10 millimeters; abdomen, 6; petiole, 2.5; terebra, 9; band, 3; apex, 1.

Male.—Frons very finely, vertex and occiput more or less coarsely transstriate, the latter with a few superficial punctures. Third flagellar joint not longer than first and second together. Petiole transstriate, much shorter than rest of abdomen. Hind femora sometimes transaciculate; tibiæ compressed to beyond middle.

Black; head and three or four basal antennal joints flavous, the black ocelli very conspicuous; anterior legs rufotestaceous; middle and hind metatarsi white. Stigma and nervures rufescent.

Length, 7 to 10 millimeters; abdomen, 3.5 to 6; petiole, 1.5 to 2.5.

SINGAPORE (*Baker*).

Though differing greatly in color, the sexes agree in sculpture, and I have no doubt that they belong together. The white femoral teeth are less distinct in the males, and in one example are almost rufescent.

Apparently closely allied to my *F. ocellatus* from Sarawak.

FOENATOPUS ACICULATUS sp. nov.

Female.—Frons finely transstriate, vertex and occiput more or less distinctly transrugose, latter basally smooth; posterior tubercles small but distinct; three or four carinæ on vertex; posterior margin of head bordered. Scape shorter than cheeks; second flagellar joint little longer than first, third barely as long as first and second together. Neck irregularly transcarinate, semiannular closely punctate, basally narrowly smooth, not quite half as long as neck. Mesonotum very short, rugose. Scutellum centrally smooth, central lobe laterally finely punctate, lateral lobes closely and coarsely punctate; mesopleuræ smooth or finely transaciculate and shining above, finely punctate beneath. Metapleuræ rather small, rugose punctate, separated by a carina from the cribrate punctate median segment. Petiole finely transstriate, as long as the smooth rest of abdomen. Terebra shorter than body, black. Hind coxæ transstriate, femora and tibiæ transaciculate, the former tridentate, latter compressed in bassal two-thirds; matatarsi about three times as long as the remaining joints. Radius emitted from apical fifth of stigma, its distal section about half as long as again as the proximal.

Black; inclining to red beneath; head and three basal antennal joints rufotestaceous, vertex and occiput dark red; pronotum sometimes rufescent; anterior legs rufescent, middle tibiæ and metatarsi basally white; hind legs dark red, their metatarsi white or pale rufescent. Femoral teeth white.

Length, 9 to 11 millimeters; abdomen, 5 to 7; petiole, 2.5 to 3; terebra, 7 to 9.

MINDANAO, Butuan, Dapitan. BASILAN, male. SIBUYAN, male. BORNEO, Sandakan (*Baker*).

Male.—Third flagellar joint as long as first and second together; petiole shorter than rest of abdomen; hind metatarsi very little longer than the remaining joints. Otherwise as in female.

Black; head, three basal antennal joints, and anterior legs rufotestaceous, vertex more reddish, outer orbits broadly white. Stigma and nervures red-brown.

Length, 9 millimeters; abdomen, 5; petiole, 2.

MINDANAO, Iligan (*Baker*).

Especially characterized by the transaciculate hind femora and tibiæ.

FOENATOPUS RUFITARSIS sp. nov.

Female.—Frons and ocellar space finely transstriate, anterior tubercles subobsolete, posterior ones broad and obtuse; vertex and occiput indistinctly transstriate, with large superficial punctures laterally; three carinæ on vertex; posterior margin of head finely bordered. Scape as long as cheeks; antennal joints short, second little longer than first, third shorter than first and second together. Neck apically transcarinate, basally smooth, semiannular half as long as neck, basally finely transstriate. Mesonotum short, finely punctate, with three distinct impressions. Central lobe of scutellum smooth, lateral lobes finely punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ rugose punctate, separated by a carina from the reticulate punctate median segment. Petiole finely transstriate, as long as, or slightly shorter than the remaining not very shining segments. Terebra shorter than body, black. Hind coxæ rather coarsely and irregularly transstriate, somewhat slender, trochanters inflated; femora about as long as coxæ tridentate; tibiæ not much longer than femora, compressed in basal two-thirds; metatarsi more than twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section half as long again as the proximal.

Black; head beneath, frons, cheeks, temples, and prothorax beneath testaceous, outer orbits slightly paler; frons and two basal antennal joints red; anterior legs and hind tarsi rufotestaceous, middle tibiæ and metatarsi basally white. Femoral teeth white. Nervures red-brown.

Length, 8 to 10 millimeters; abdomen, 4.5 to 6; petiole, 2 to 3; terebra, 7 to 9.

MINDANAO, Iligan. LUZON, Mount Limay (*Baker*).

Small denticulations behind the basal femoral tooth and those between it and the middle tooth are replaced by white bristles. In the example from Luzon the head is rather darker.

FOENATOPUS RUBRICAPUT sp. nov.

Female.—Frons apically transversely, basally arcuately, vertex and occiput very finely transversely striate, latter basally almost smooth with deep longitudinal sulcus; two carinæ on vertex; posterior margin of head bordered; posterior tubercles well developed. Scape longer than cheeks; antennæ normal. Neck elongate, finely transstriate, the semiannular smooth. Meso-

notum transrugose, the impressions obsolete. Scutellum centrally mooth, lateral lobes irregularly rugose; mesopleuræ smooth, basally transaciculate. Metapleuræ and median segment coarsely punctate, separated by a carina. Petiole transstriate, shorter than the remaining smooth segments. Terebra slightly shorter than body, banded. Hind coxæ transstriate, femora tridentate, smooth, rather longer than the coxæ; tibiæ very slightly longer than the femora, compressed beyond middle; metatarsi three times as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal section more than twice as long as the proximal.

Black; head red, with an indistinct paler line under eyes; anterior legs red, middle tibiæ and metatarsi basally white; scape rufotestaceous, flagellum basally rufescent.

Length, 19 millimeters; abdomen 13, petiole, 6; terebra, 18; band, 4.

BORNEO, Sandakan (*Baker*).

FOENATOPUS INSULARIS sp. nov.

Female.—Frons rather coarsely, vertex and occiput very finely transstriate, latter basally narrowly smooth; two carinæ between posterior ocelli; posterior margin of head finely bordered; posterior tubercles small but distinct. Scape shorter than cheeks; antennæ normal. Neck long and slender, transstriate, basally and the semiannular smooth. Mesonotum rugose, central impression indicated, lateral ones obsolete. Scutellum smooth, all lobes laterally punctate; mesopleuræ smooth above, otherwise punctate. Metapleuræ and median segment cribrate punctate, separated by an indistinct carina. Petiole very finely transstriate, shorter than the smooth rest of abdomen. Terebra slightly longer than body, white-banded. Hind coxæ finely transstriate, as long as the tridentate, apically transaciculate femora; tibiæ a little longer than femora, compressed about to middle; metatarsi three times as long as the remaining joints. Radius emitted from near apex of the long, narrow stigma, both sections of the same length.

Black; head red, ocellar space black, carinæ bright red, vertex nigrescent; antennæ basally, terebra, anterior legs, and hind tibiæ rufescent; middle tibiæ basally and basal half of their metatarsi whitish.

Length, 16.5 millimeters; abdomen, 11; petiole, 5; terebra, 17; band, 3.

Male.—Agrees with the female in sculpture in all essentials; the petiole is as long as rest of abdomen; hind femora entirely smooth, metatarsi about as long as the remaining joints.

Head red beneath base of antennæ, apex of frons and outer orbits testaceous, antennæ centrally rufescent, becoming black toward apex; anterior legs rufescent, middle metatarsi whitish.

Length, 13.5 millimeters; abdomen, 9; petiole, 4.5.

BASILAN (*Baker*).

This appears to be a purely insular variety. In both sexes the basal femoral tooth is small, and the male might almost be considered bidentate; but the sexes undoubtedly belong together.

FOENATOPUS TRANSVERSUS sp. nov.

Female.—Head very short, transverse; frons, vertex, and the extremely short occiput finely transstriate; two carinæ on vertex; posterior margin of head bordered finely. Scape longer than cheeks; first flagellar joint very short, second and third about equal in length, all antennal joints indistinctly discreted. Neck elongate, semiannular short, both smooth and shining. Mesonotum very short, indistinctly sculptured. Scutellum smooth; mesopleuræ smooth and very shining. Metapleuræ and median segment confluent, superficially and not very closely punctate, latter centrally almost smooth. Petiole feebly transstriate, shorter than rest of abdomen, which is very shining. Terebra shorter than body, slightly rufescent, white-banded. Hind coxæ transstriate, femora bidentate, finely transaciculate; tibiæ much longer than femora, smooth, compressed in basal two-thirds; metatarsi twice as long as the remaining joints. Radius emitted from very near apex of stigma, its distal section not quite half as long again as the proximal.

Rufescent; head and two basal antennal joints rufotestaceous, vertex and occiput nigro-rufous; anterior legs rufotestaceous, hind tarsi red. Femoral teeth white. Stigma and nervures blackish.

Length, 8.5 millimeters; abdomen, 4.5; petiole, 2; terebra, 6.5; band, 0.75.

PANAY, northwestern part (*Baker*).

This species is characterized by the transverse head, the formation of the antennæ, and the long smooth neck.

FOENATOPUS OCELLATUS Elliott.

Foenatopus ocellatus ELLIOTT, Entomologist 52 (1919) 131; Proc. Zool. Soc. London (1922) 784.

FOENATOPUS LACTEIPENNIS Schletterer.

Foenatopus lacteipennis SCHLETTERER, Berl. Ent. Zeit. 33 (1899) 119; ELLIOTT, Proc. Zool. Soc. London (1922) 790.

FOENATOPUS RUFESCENS sp. nov.

Female.—Frons arcuate striate with narrow central longitudinal sulcus; vertex and occiput finely subarcuate striate; ocellar space longitudinally carinate; two carinæ behind posterior ocelli; posterior margin of head bordered; posterior tubercles distinct. Scape as long as cheeks; antennæ normal. Neck coarsely transstriate, basally smooth, semiannular apically finely striate, basally smooth. Mesonotum finely transcarinate, with central impression only. Scutellum centrally smooth, lateral lobes coarsely punctate; mesopleuræ smooth above, punctate beneath. Metapleuræ coarsely punctate, apically smooth above, separated by an indistinct carina from the reticulate punctate median segment. Petiole extremely finely transstriate, longer than the remaining smooth segments. Terebra longer than body, yellow-banded. Hind coxæ transstriate, about as long as the smooth, bidentate femora; tibiæ a little longer than femora, compressed to middle; metatarsi three times as long as the remaining joints. Radius emitted from end of second third of stigma, its distal section little longer than the proximal.

Rufescent; anterior legs lighter; base of mandibles, face, cheeks and temples, scape and first flagellar joint, frons centrally longitudinally, and base of anterior tubercle rufotestaceous.

Length, 18.5 millimeters; abdomen, 12.5; petiole, 7; terebra, 20; band, 5.

BORNEO, Sandakan (*Baker*).

FOENATOPUS DUBIUS sp. nov.

Female and male.—Frons arcuate striate, vertex and occiput finely transstriate, latter basally smooth; a fine longitudinal sulcus on vertex and three carinæ; posterior margin of head bordered; posterior tubercles well developed. Scape almost shorter than cheeks; antennæ normal. Neck finely transstriate, basally smooth above, semiannular smooth, laterally diffusely punctate. Scutellum and mesopleuræ smooth. Metapleuræ and median segment rather superficially reticulate punctate, separated by a carina and a line of punctures. Petiole rather finely transstriate, as long as the rest of the somewhat dull abdomen. Terebra about as long as body, white-banded. Hind

coxæ finely transstriate, as long as the extremely finely transaciculate, bidentate femora; tibiæ smooth, longer than femora, compressed to slightly beyond middle; metatarsi fully three times as long as the remaining joints in female, little longer in male. Radius emitted from apical fourth of stigma, its distal section not quite as long as the proximal.

Black; head red beneath, black above, the apices of the tubercles rufescent; frons light red in female, apically rufotestaceous in male; base of antennæ light red; petiole, second abdominal segment, and hind legs red; anterior legs rufotestaceous, middle tibiæ basally and their metatarsi entirely white; hind metatarsi red.

Length, 12, to 13.5 millimeters; abdomen, 8; petiole, 4; terebra, in female, 12; band, 2.5; apex, 1.

MINDANAO, Davao (*Baker*).

Apparently closely allied to my *F. longicoxis*, but the hind coxæ, though similar in shape, are shorter and stouter, and the metapleuræ are separated from the median segment by a carina.

FOENATOPUS ATRIPES Kieffer.

Foenatopus atripes KIEFFER, Philip. Journ. Sci. § D 9 (1916) 410.

FOENATOPUS INTERMEDIUS sp. nov.

Female.—Frons arcuately, vertex and occiput very finely transversely striate; one carina between the posterior ocelli and another shorter one behind it; posterior margin of head bordered; all tubercles distinct. Scape barely as long as cheeks; antennæ normal. Neck very elongate, extremely finely transstriate, basally and the semiannular smooth. Mesonotum lightly, irregularly rugose, the central impunctate impression distinct, lateral ones obsolete. Scutellum and mesopleuræ smooth. Metapleuræ basally transrugose, apically, like the median segment cribrate punctate, separated basally only by an indistinct line of punctures. Petiole transstriate, shorter than rest of abdomen, second segment basally rugose. Terebra slightly shorter than body, white-banded. Hind coxæ fusiform, basally and apically finely transstriate, centrally smooth, rather longer than the bidentate femora, which are apically finely transaciculate; tibiæ not much longer than femora, transaciculate, compressed in basal three-fifths; metatarsi three times as long as the remaining joints. Radius emitted from apical fifth of stigma, the sections about equal in length.

Black; head beneath, cheeks, and temples red, frons and outer orbits flavescent, vertex and occiput black, scape flavescent, three or four basal flagellar joints red. Anterior legs red, their tibiæ and tarsi rufotestaceous; hind legs rufescent, tibiæ and tarsi slightly paler. Stigma and nervures red-brown.

Length, 11.5 millimeters; abdomen, 8; petiole, 3.5; terebra, 11; band, 2; apex, 0.75.

BASILAN (*Baker*).

The neuration of this species is intermediate between *Foenatopus* and *Diastephanus*, the portion of the median nervure beyond the basal cells being distinct but feebly pigmented. It is characterized by the elongate neck, shape of hind coxæ, sculpture of hind femora and tibiæ, and color.

FOENATOPUS LONGICOLLIS Cameron.

Foenatopus longicollis CAMERON, Trans. Am. Entom. Soc. Philadelphia 18 (1889) 32; ELLIOT, Proc. Zool. Soc. London (1922) 790.

FOENATOPUS MAZARREDOI Caballos.

Foenatopus mazarredoi CABALLOS, "Eos" II, 2 & 3, p. 144.

FOENATOPUS TERECOLLIS sp. nov.

Female.—Frons, vertex, and occiput finely transstriate, latter basally smooth; three costæ on vertex; ocellar space oblique striate; posterior margin of head bordered. Scape longer than cheeks; antennæ normal. Neck elongate, finely transstriate; basally smooth, as is the semiannular. Mesonotum short, irregularly rugose, central row of punctures indicated. Central lobe of scutellum smooth, lateral lobes dull and indistinctly sculptured; mesopleuræ smooth above, finely punctate beneath. Metapleuræ and median segment cribrate punctate, confluent. Petiole finely transstriate, shorter than rest of abdomen. Terebra about as long as body, yellow-banded. Hind coxæ finely transstriate, as long as the bidentate femora; tibiæ little longer than femora, compressed to beyond middle; metatarsi rather more than twice as long as the remaining joints. Radius emitted from apical third of stigma, its distal section twice as long as the proximal.

Black; head and base of antennæ red, vertex nigrescent; middle tibiæ and metatarsi rufescent, basally white. Stigma and nervures rufescent.

Length, 16 millimeters; abdomen, 10; petiole, 4.5; terebra, 16; band, 5; apex, 1.

BORNEO, Sandakan (*Baker*).

FOENATOPUS SIBUYANUS sp. nov.

Female.—Frons indistinctly, subgranulately, vertex and occiput finely transversely striate, two carinæ between posterior ocelli, ocellar space rugose, all tubercles well developed; posterior margin of head bordered. Scape as long as the cheek; antennæ normal. Neck elongate and very finely transstriate, semiannular apically transstriate, basally smooth, laterally punctate. Mesonotum very short, rugose, central row of punctures indicated, lateral one obsolete. Scutellum centrally smooth, marginal punctures fine, lateral lobes diffusely punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ and median segment reticulate punctate, confluent. Petiole extremely finely punctate, shorter than the remaining segments. Terebra a little longer than body, white-banded. Hind coxæ finely and evenly transstriate, as long as the smooth bidentate femora; tibiæ as long as femora and trochanters, compressed to middle; metatarsi twice as long as the remaining joints. Radius emitted from apical third of the elongate stigma, its distal section about twice as long as the proximal.

Black; head rufotestaceous, face paler, vertex red; median segment, petiole, and hind legs rufescent, anterior legs rufotestaceous; stigma and nervures red-brown.

Length, 17 millimeters; abdomen, 11; petiole, 5; terebra, 18; band, 3.

SIBUYAN (*Baker*).

Characterized by the sculpture of the frons, the very short mesonotum, and confluent metapleuræ and median segment.

FOENATOPUS INDICUS (Westwood).

Stephanus indicus WESTWOOD, Ann. & Mag. Nat. Hist. 7 (1841) 588.
Foenatopus indicus ENDERLEIN Zool. Anz. 41 (1913) 290; ELLIOTT, Proc. Zool. Soc. London (1922) 784.

FOENATOPUS SUMBANUS Enderlein.

Foenatopus sumbanus ENDERLEIN ZOOL. Anz. 41 (1913) 209; ELLIOTT, Proc. Zool. Soc. London (1922) 785.

FOENATOPUS LABRICOXIS sp. nov.

Female.—Frons rugose, centrally subgranulately, vertex and occiput finely, transstriate, three strong carinæ behind posterior ocelli, all tubercles distinct; posterior margin of head finely bordered. Scape about as long as cheeks; antennæ normal. Pronotum smooth, neck elongate, with faint indication of transstriation behind the apical impression. Mesonotum short, indistinctly punctate, the usual rows of punctures obsolete. Scu-

tellum smooth, sutures punctate; mesopleuræ basally finely aciculate, apically smooth above, diffusely punctate beneath. Metapleuræ and median segment cribrate punctate, separated by an indistinct carina. Petiole very finely transstriate, shorter than the remaining smooth segments. Terebra as long as body, whitish-banded. Hind coxæ so finely sculptured as to appear smooth; femora bidentate, as long as the coxæ; tibiæ little longer than the femora, compressed to slightly beyond middle; metatarsi nearly three times as long as the remaining joints. Radius emitted from apical third of stigma, its distal section twice as long as the proximal.

Black; head beneath, face and base of antennæ rufotestaceous, a pale line under eyes; neck, petiole, second and third abdominal segments rufescent or black; legs light rufescent, middle tibiæ and metatarsi basally whitish. Stigma and nervures rufescent.

Length, 14 millimeters; abdomen, 9; petiole, 4; terebra, 14; band, 2.5.

MINDANAO, Davao (*Baker*).

This species bears a strong resemblance to *F. indicus* (Westwood), but the petiole is shorter than rest of abdomen, terebra only as long as body, hind coxæ and femora smooth and polished.

FOENATOPUS FLAVIFRONS Elliott.

Foenatopus flavifrons ELLIOTT, Philip. Journ. Sci. 29 (1926) 525. Male.

To the original description add:

Length, 8.5 millimeters; abdomen, 5.5; petiole, 2.

FOENATOPUS PICTICEPS sp. nov.

Male.—Frons and vertex finely transstriate, occiput centrally indistinctly striate, laterally strongly punctate, basally narrowly smooth; three carinæ on vertex; posterior margin of head bordered; all tubercles distinct. Scape longer than cheeks; antennæ normal. Pronotum apically carinate, otherwise transstriate. Mesonotum short, diffusely punctate, with three deep impressions. Scutellum centrally smooth, lateral lobes punctate; mesopleuræ smooth above, finely punctate beneath. Metapleuræ coarsely punctate, separated by a carina from the median segment, which is apically smooth and shining, otherwise diffusely and superficially punctate. Petiole transstriate, shorter than rest of abdomen. Hind coxæ transstriate, femora tridentate and, like the tibiæ, very finely transaciculate; metatarsi nearly

twice as long as the remaining joints. Radius emitted from apical fourth of stigma, its distal not twice as long as the proximal.

Black; head beneath, face, apical half of frons, outer orbits partly, and scape flavous, vertex and occiput red, upper half of frons and ocellar space black; anterior legs rufescent, middle tibiæ and metatarsi white. Stigma black bordered, nervures rufescent.

Length, 10 millimeters; abdomen, 6.5; petiole, 2.5.

SINGAPORE (*Baker*).

Resembles *F. flavifrons* in the color of the femoral teeth, but differs much in sculpture, especially of the vertex and occiput.

FOENATOPUS ALBICEPS sp. nov.

Male.—Frons rather elongate, finely subarcuate striate, five carinæ on vertex, behind which it is transstriate, occiput more or less rugose; posterior margin of head bordered. Scape shorter than cheeks; antennæ normal, first joint stout. Pronotum apically coarsely, basally more finely transstriate, semiannular rugose punctate. Mesonotum rugose, the three impressions distinct. Scutellum and mesopleuræ smooth, the former rather dull. Metapleuræ somewhat coarsely punctate, separated apically only by an indistinct sulcus and carina from the alutaceous, diffusely punctate median segment. Petiole finely and evenly transstriate, shorter than the rest of the smooth abdomen. Hind coxæ evenly transstriate, femora transaciculate, tridentate; tibiæ much longer than femora, compressed in basal two-thirds. Radius emitted from apical fourth of stigma, its distal section scarcely twice as long as the proximal.

Black; head beneath, frons more or less, outer orbits, cheeks, and temples white; mandibles basally, scape and first flagellar joints testaceous, rest of frons, ocellar space, and occiput black; tubercles, carinæ on vertex, and a central longitudinal line on frons red; prosternum, front coxæ, and femora teeth white; anterior legs rufotestaceous, middle metatarsi paler; hind legs rufescent, their tarsi rufous. Stigma and nervures blackbrown.

Length, 9.5 to 10.5 millimeters; abdomen, 5 to 6.5; petiole, 2 to 2.5.

BASILAN (*Baker*).

The sculpture of the head, its color, and the white front coxæ are characteristic.

FOENATOPUS LONGICOXIS sp. nov.

Male.—Frons indistinctly rugose, vertex and occiput finely and indistinctly transstriate, with a broad central sulcus, not reaching the bordered posterior margin of head; three carinæ on vertex; posterior tubercles distinct. Scape as long as cheeks; antennæ normal. Neck elongate, transstriate, basally smooth, semiannular smooth and shining, with transverse line of fine punctures and lateral angles transstriate. Mesonotum smooth and shining, lateral rows of punctures distinct, the central one basally only. Scutellum smooth, central lobe with fine marginal punctures; mesopleuræ smooth, basally punctate, and a few apical punctures. Metapleuræ and median segment coarsely punctate, confluent. Petiole transstriate, as long as rest of abdomen, second segment basally rugose and dull, then smooth and shining, the rest rather dull. Hind coxæ strongly clavate, transstriate, longer than the transaciculate, tridentate femora; tibiæ a little longer than femora, compressed to middle; metatarsi scarcely longer than the remaining joints. Radius emitted from apical fourth of stigma, its sections about equally long.

Black; base of mandibles, apex of frons, five or six basal antennal joints, and outer orbits rufescent or red: anterior legs rufescent, middle metatarsi paler; hind legs, including the tarsi, black. Stigma and nervures red-brown.

Length, 11 to 16 millimeters; abdomen, 7 to 10; petiole, 3.5 to 5.

MINDANAO, Davao (*Baker*).

Especially characterized by the indistinct sculptures of the head, the long, clavate hind coxæ, and the black hind tarsi.

THE GOATFISHES, OR MULLIDÆ, OF THE PHILIPPINES

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SIX PLATES

MULLIDÆ

GOATFISHES, OR SURMULLETS

Ilocano name, *balaki;* Tagalog, *tuyo;* Tao Sug and Samal, *mangentut, tangbod, tiao, timbuñgan;* Visayan, *bayabao, tiao, timbungan.*

The members of this family may be recognized at a glance by their general physiognomy, and the presence of two long, firm, unbranched barbels below the chin, attached just behind the symphysis; the elongate, slightly compressed body is covered with large and usually slightly ctenoid scales; the profile of the head is more or less parabolic; the mouth is small, low, subterminal, the premaxillaries slightly protractile; the teeth are mostly small, weak, the dentition more or less complete, without canines, incisors, or molars; eye is of medium size, lateral, high up, near the middle or in the posterior half of the head; two dorsal fins, far apart, both short, the first of six to eight spines; anal similar to second dorsal, with one or two small spines; ventrals thoracic, I–5; lateral line continuous, the tubules often branched; a simple air bladder usually present; stomach siphonal, pyloric cæca, about 20; branchiostegals, 4; pseudobranchiæ present.

This family includes forty or fifty species, belonging to five very closely related genera. They are shore or reef fishes found in all warm seas, some representatives occurring in the temperate waters of Asia, Europe, North America, and Australia. The goatfishes are bottom dwellers, and as they creep about over the sea floor keep their barbels incessantly in motion, feeling and testing everything as they seek their food. They are carnivorous, and feed upon small animals, such as crustaceans and small fishes living on the bottom and around stones.

Many of the species are brilliantly colored, often with much red or golden, and usually with a red layer of pigment beneath, which appears when the fish is scaled or placed in alcohol. These colors however are not permanent, and are apt to disappear in most preserved specimens.

The flesh of the goatfishes is white, tender, and of very fine flavor. Several kinds are important and highly valued food fishes. Some of them are rather small, and none attains great size, the largest being little more than half a meter in length. They do not take the hook readily but may be caught in traps or bobos, in trammel and gill nets, and by the Japanese muro ami method.

Key to the genera of Mullidæ.

Only the first three genera are found in the Philippines.

a^1. Dentition complete; teeth in both jaws, on vomer, and on palatines. **Upeneoides.**

a^2. Dentition more or less incomplete, never complete.

b^1. Upper jaw with teeth.

c^1. No teeth on palate.

d^1. Teeth of jaws comparatively strong, in a single row.... **Upeneus.**

d^2. Teeth of jaws in several rows or in a villiform band **Mulloides.**

c^2. Vomer and both jaws with teeth, none on palatines.... **Upeneichthys.**

b^2. Upper jaw toothless; lower jaw, vomer, and palatines with teeth. **Mullus.**

Genus UPENEOIDES Bleeker

Upeneoides BLEEKER, Verh. Bat. Gen. 22 (1849) 64; Günther, Cat. Fishes 1 (1859) 397.

This genus is recognized at once by the presence of small acute teeth in several rows in both jaws, and on the vomer and palatines.

The species are not very numerous, distributed throughout the warmer regions of the Indian and Pacific Oceans, but absent from the west coast of tropical America. Six species are here described from the Philippines. A number of species live in sandy bays, where their brown mottled coloration blends perfectly with play of light and shadow on the gray and yellowish sea bottom.

Key to the Philippine species of Upeneoides.

a^1. Head completely scaled; a brown or blackish band from eye to caudal.

b^1. A brown saddle over anterior half of caudal peduncle; one or two dark crossbands on side; each lobe of caudal with six or more oblique dusky bands..... **U. luzonius.**

b^2. No saddle on caudal peduncle and no crossbands.

c^1. Body not spotted; first dorsal clear, unspotted; second dorsal with five longitudinal yellow stripes; upper lobe of caudal with four or five yellow crossbars..... **U. sundaicus.**

c^2. Head and body spotted with blackish; first dorsal black, with rounded pale spots; each lobe of caudal with four to six blackish bars ..... **U. tragula.**

a^2. Head not completely scaled; preorbital partly or entirely naked; longitudinal bands yellow, or disappearing in alcohol.

d^1. A bright yellow band from eye to caudal; dorsals and upper lobe of caudal with alternate yellowish and blackish bands; preorbital partly naked..... **U. moluccensis.**

d^2. Two or more longitudinal stripes on body.

e^1. A bright yellow band from eye to caudal and one from axil of pectoral to caudal; preorbital partly naked; caudal not barred. **U. sulphureus.**

e^2. Four or five yellow longitudinal lines on side; caudal with four or five oblique black bands on each lobe; preorbital naked. **U. vittatus.**

UPENEOIDES LUZONIUS (Jordan and Seale). Plate 1, fig. 1.

Upeneus luzonius JORDAN and SEALE, Bull. Bur. Fisheries **26** (1907) 25, fig. 9.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–32 to 34–$6\frac{1}{2}$.

Body moderately elongate, its greatest depth 3.8 to 3.9 times, head 3.3 to 3.4 times in length; the nearly flat interorbital space 3.6 to 3.7 times in head; eye located high up near upper profile of head and about midway between tip of snout and posterior margin of opercle, 4 to 4.4 times in head; snout 1.6 to 1.9 times in eye and about as long as maxillary which is 2.4 to 2.5 times in head and reaches posteriorly to almost below anterior rim of pupil; lower jaw slightly the shorter; teeth villiform in jaws, and on vomer and palate; 5 or 6 + 15 gill rakers on first arch, the longest about half the eye; the long slender barbels extend to a little beyond angle of the smooth preopercle; only a single spine at hind edge of opercle; head, including preorbital and maxillary, completely covered with scales; least depth of caudal peduncle 2.2 to 2.4 times in head.

Spinous dorsal rather high, its first spine minute, the second highest, 3.4 to 4 times in length of body; second dorsal and anal of nearly the same height, 1.7 to 1.9 times in head; pectoral very sligthly shorter than ventral, which is 1.3 to 1.5 times in head, the latter fin reaching to the vertical from axil of first dorsal; caudal about as long as head, 3.1 to 3.5 times in length of body.

Alcoholic specimens are dull yellowish to yellowish brown, with a dark brown longitudinal band running from eye to

caudal; a brown saddle over anterior half of caudal peduncle; a rather indistinct vertical band of the same color descends the side from the anterior two-thirds of the rayed dorsal; another brown band sometimes present below the spinous dorsal; dorsals clouded indistinctly with dusky, these markings oftentimes inconspicuous; each lobe of caudal crossed by six or more oblique dusky bands which are rather fine and about as wide as the interspaces; all the other fins yellowish, unmarked; no dusky spots visible on sides of head and body.

This species is here described from thirty-one examples, 57 to 105 millimeters long, coming from the following loacalities:

Orani, Bataan, 11.
Manila, 4.
Pasay, Rizal Province, 1.
San Miguel, 3.
Capiz, Capiz, 1.
San Pedro Bay, 1.
Tacloban, Leyte, 1.
Cuyo, 1.
Sandakan, Borneo, 8.

This species is very closely allied to *Upeneoides vittatus* (Forskål) from which it differs in the presence of brown transverse bands above the lateral line, in the absence of dusky spots on sides, and in having finer dusky crossbands on each lobe of caudal. In many alcoholic examples of this species, the color markings on the dorsals have faded.

Jordan and Seale had specimens from Cavite, caught in Manila Bay. A living specimen in the Bureau of Science aquarium was mostly gray in color, the longitudinal band and fin markings dusky, but it died before complete color notes could be taken. This small inconspicuous species is of no particular importance as a food fish.

UPENOIDES SUNDAICUS Bleeker.

Upeneoides sundaicus BLEEKER, Act. Soc. Sci. Indo-Neerl. 2 (1857) 47; GÜNTHER, Cat. Fishes 1 (1859) 399.

Upeneus sundaicus BLEEKER, Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 10; Atlas Ichth. 9 (1875) pl. 394, fig. 2; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Dorsal VIII–I, 8 or 9; anal II, 6 or 7; scales 2–32 to 35–5.

Body elongate compressed, depth 3.75, head 3.5 times in length; height of head 1.25 to 1.2 times in its own length; anterior dorsal profile very strongly convex; eye 3.5 to 4 times in head; interorbital 4 in head; the convex abtuse snout almost entirely scaled; maxillary extends under anterior half of eye, 2.3 to 2.6 in head; the barbels touch or nearly touch posterior margin of preopercle.

Spinous dorsal equals or is a little lower than depth, dorsal rays much higher, first dorsal spine small, second spine highest; soft dorsal and anal subequal in height; pectoral and ventrals acutely rounded, 6 or somewhat less than 6 in length; caudal deeply incised, lobes acute, lower shorter than upper, 4.75 to 5 times in length.

Color above violaceous olive, paler on sides, belly golden rose; a moderately wide stripe from eye to tail, fuscous to violaceous dusky intersecting the lateral line under soft dorsal; eye yellowish; barbels golden; fins rosy hyaline; soft dorsal with 5 longitudinal yellow stripes; upper lobe of caudal with 4 or 5 yellow transverse stripes, posterior margin of lower lobe violet.

In alcohol it is yellowish, with an indistinct dusky line from eye to caudal.

The above description is compiled from Bleeker and Evermann and Seale. The latter had a specimen "5.1 inches in length" from Bacon, Sorsogon. We have seen no specimens.

Bleeker had 17 specimens, 115 to 181 millimeters in length, obtained in various localities from Sumatra to Celebes and Buru, one of the Moluccas.

UPENEOIDES TRAGULA (Richardson). Plate 2, fig. 1.

Upeneus tragula RICHARDSON, Ichth. China, Rept. Brit. Asso. Adv. Sci. (1845) 220; BLEEKER, Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 11; Atlas Ichth. 9 (1878) pl. 392, fig. 2; JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 782; Bull. Bur. Fisheries 26 (1907) 26; JORDAN and EVERMANN, Bull. Bur. Fisheries 26 (1907) 88; WEBER, Fische, Siboga Exp. (1913) 293.

Upeneoides tragula GÜNTHER, Cat. Fishes 1 (1859) 398; Day, Fishes of India (1878) 121, pl. 30, fig. 4; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260; SEALE, Philip. Journ. Sci. § D 5 (1910) 278; 9 (1914) 68; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 43.

Upeneoides variegatus BLEEKER, Verh. Bat. Gen. 22 (1849) 64.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–31–$6\frac{1}{2}$.

The elongate body rather low, its greatest depth 4 to 4.5 times in length, upper profile gently arched from snout to first dorsal; head 3.2 to 3.7 times in length of body; interorbital space very slightly convex, its least width 3.4 to 3.8 times in head; eye located high up near upper profile of head, 4 to 4.9 times in head; snout moderate and rather obtuse anteriorly, 1.7 to 2.1 times eye or 2.3 to 2.4 times in head; maxillary round posteriorly and as long as snout, its posterior end beneath anterior margin of pupil; lower jaw slightly shorter than upper;

teeth villiform in jaws, vomer, and palate; 6 + 16 or 17 gill rakers on first arch; the barbels do not quite reach angle of preopercle; both inferior and posterior limbs of opercle smooth; two spines at hind border of opercle, upper one smaller and hidden under a scale; least depth of caudal peduncle 2.3 to 2.7 times in head; entire head, including preorbital, maxillary, and chin, covered with scales.

First dorsal spine minute, second spine highest, 1.4 to 1.6 times in head; soft dorsal and anal equal in height, 1.6 to 1.9 times in head; pectoral a little shorter than ventral, the latter 1.3 to 1.5 times in head and reaching about halfway from its origin to base of posterior anal rays; the deeply forked caudal longer than head, 3 to 3.5 times in length of body.

Living specimens are grayish yellow; head and body sparingly and irregularly spotted with brownish; upper half of spinous dorsal black, sprinkled with yellow rounded spots, basal half with two rather faint dusky broad bands; the soft dorsal has two or three rather indistinct dusky longitudinal bands; each lobe of the caudal has oblique dusky bands which are broader than the interspaces; all the other fins barred or spotted with brown; a dusky stripe runs from snout through eye to base of caudal fin; barbels deep coral red.

Living specimens at Calapan had the ground color pale or gray, thickly spotted with brownish above, each scale on lower half of body with a conspicuous brown spot; sides of head with brown spots; a brown band through eye to caudal; ventral region white or with a roseate flush; dorsals and caudal as already described; pectoral yellowish, with reddish brown spots; anal and ventrals yellow, crossbarred with red spots. The colors of this fish blend perfectly with the mottled sandy sea bottom.

The color in spirits is brownish above, passing into yellowish below; a dark brown to blackish band extends from snout through eye to caudal fin; head and body spotted with dark brown to blackish; first dorsal clouded with blackish, which is spotted with whitish, second dorsal clouded with blackish; each lobe of caudal with four to six oblique blackish bars, those on lower lobe broader; the number of these bars usually smaller in younger individuals; pectoral, ventral, and anal spotted or barred with dusky color.

We have examined numerous specimens of this species in the Bureau of Science collection, measuring 39 to 175 millimeters in length. They were obtained at the following localities:

Luna and Camp Walace, La Union, 8.
Alaminos, Pangasinan, 1.
Olongapo, Zambales, 3.
Malabon, Rizal, 2.
Puerto Galera and Calapan, Mindoro, 8.
Bacon, Sorsogon, 1.
Legaspi, Albay, 1.
Dicuayan Island and Concepcion, Busuanga, 2.
Culion Island, 2.
Catbalogan and Borongan, Samar, 2.
New Washington, Panay, 85.
Bantayan Island, 9.
Cuyo, 1.
Jordan, Guimaras, 1.
Cebu, Cebu, 1.
Puerto Princesa, Palawan, 2.
Palawan Island, 1.
Tagbilaran, Bohol, 2.
Dumaguete, Oriental Negros, 1.
Cagayan de Misamis, 7.
Balabac Island, 8.
Davao, Davao, 5.
Caldera Bay and Zamboanga, 10.
Basilan Island, 1.

One of the specimens, 172 millimeters in length, taken at Puerto Galera in April, 1912, is a female nearly ready to spawn. The Philippine examples are not different from several representatives from Hongkong and Sandakan, which are also in the Bureau of Science collection. The maximum size of this species is about 250 millimeters.

This fish has been reported previously from the Philippines by Günther; from Manila, Iloilo, and the southern coast of Negros by Jordan and Seale; from Bacon, Sorsogon, by Evermann and Seale; from Cuyo by Jordan and Richardson; and from Cebu and Zamboanga by Fowler and Bean.

This is an important food fish in some localities. It ranges from the southern coast of China, Amboina, westward to the Andamans, Hindustan, and the east coast of Africa.

UPENOIDES MOLUCCENSIS Bleeker. Plate 6, fig. 1.

Upeneoides moluccensis BLEEKER, Nat. Tijds. Ned. Ind. 8 (1855) 409; GÜNTHER, Cat. Fishes 1 (1859) 399; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 8; Atlas Ichth. 9 (1875) pl. 392, fig. 1; SEALE, Philip. Journ. Sci. § D 9 (1914) 68. pl. 392, fig. 1; SEALE, Philip. Journ. Sci. § D 9 (1914) 68.

Dorsal VIII–9; anal 7; scales 2–32 or 33 + 5 or 6–6.

Greatest depth of body 3.8 to 4.2 times in length; head contained 3 to 3.4 times in length, its upper outline strongly arched; the nearly flat interorbital space a little wider than eye, 3.4 to 3.8 times in head, with a low longitudinal depression along its middle portion; eye rather large, 3.8 to 4 times in head, its upper edge almost touching upper outline of head; the mod-

erately short snout steep anteriorly, scaled above, 2.3 to 2.6 times in head, and 1.5 to 1.7 times eye; maxillary almost as long as snout, 2.5 to 2.6 times in head; mouth horizontal, with lower jaw very slightly included; teeth villiform on jaws, vomer, and palatines; first gill arch has 8 + 20 or 21 rakers which are rather long and slender; the barbels are rather short and barely reach vertical edge of preopercle; preopercle smooth, opercle armed behind with two flat weak spines; least depth of caudal peduncle 2.8 to 3.3 times in head, preorbital partially covered with scales, the rest of head completely scaly.

Second dorsal spine highest, 1.4 to 1.6 times in head, first very small; second dorsal and anal about equal in height, 2 to 2.7 times in head, their second rays the highest, pectoral much longer than ventral which is 1.6 to 1.8 times in head and extends halfway between its origin and that of anal; caudal deeply forked, its upper lobe slightly the longer, 3.4 to 3.8 times in length.

In life the ground color is pink to deep cherry red or purplish red above, bluish white on the middle of sides, and pinkish below; head red anteriorly, pearly bluish posteriorly, and below an extremely bright lemon yellow horizontal band runs from eye to caudal, a narrower and less-pronounced one above lateral line; one or two others may be present along lower half of body, dorsal pale pearly bluish, tipped with blackish and barred longitudinally with yellowish orange; second dorsal similarly colored, without the blackish tips; the pinkish caudal tipped with blackish, its upper lobe with seven reddish orange cross stripes; pectoral reddish, with a light wash of yellowish; rays of ventrals and anal yellowish, the membranous portions very pale pearly bluish.

In alcohol the ground color pinkish to yellowish; a bright lemon yellow lateral band runs from hind border of eye to caudal fin; upper lobes of caudal and dorsals have alternate yellowish and blackish bands; lower lobe of caudal edged posteriorly with blackish; pectoral nearly colorless, ventrals and anal whitish to yellowish.

We have examined seven specimens of this species in the Bureau of Science collection, ranging from 54 to 135 millimeters in length. They were collected at the following localities: Manila; Balayan Bay, Batangas; Pinamalayan, Mindoro; Tagbilaran, Bohol; Larena, Siquijor. The collection also contains 11 examples from Hongkong.

Bleeker had specimens from Celebes, Sumbawa, and Amboina. No one else seems to have collected it except Seale, who found specimens in the market at Hongkong.

UPENEOIDES SULPHUREUS (Cuvier and Valenciennes.) Plate 3, fig. 1.

Upeneus sulphureus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 331; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 4; Atlas Ichth. 9 (1878) pl. 393, fig. 4; JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 26; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88; SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 99; WEBER, Fische, Siboga Exp. (1913) 293.

Upeneoides sulphureus BLEEKER, Act. Soc. Sci. Indo-Neerl. 2 (1857) Vischfauna Amboina, 45; GÜNTHER, Cat. Fishes 1 (1859) 398; DAY, Fishes of India (1878) 120, pl. 30, fig. 3; STEINDACHNER and DÖDERLEIN, Fische Japan 2, Denks. Akad. Wiss. Wien 48 (1884) 23; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260; SEALE, Philip. Journ. Sci. § D 5 (1910) 279; (1914) 68.

Upeneus bivittatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 390.

Upeneoides fasciolatus DAY, Proc. Zool. Soc. (1868) 151.

Upeneus pinnifasciatus STEINDACHNER, Sitzber. Akad. Wiss. Wien 61 (1870) Abth. 1, 624.

Upeneoides belaque FOWLER, Proc. Akad. Nat. Sci. Phila. 70 (1918) 40, fig. 16.

Pangasinan name, *balaki*.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–35–$6\frac{1}{2}$.

Body evenly arched above, its greatest depth 3.2 to 3.5 times in length; head equal to or slightly longer than depth of body, 3.1 to 3.5 times in length; the almost flat interorbital space as wide as the moderately large eye, which is 3.6 to 4.1 times in head; upper edge of eye almost even with dorsal contour of head; snout fairly short, its length 1.3 to 1.7 times eye or 2.3 to 2.7 times in head, its upper outline steep anteriorly; maxillary equal to or slightly longer than snout, 2.3 to 2.4 times in head, and extending below anterior third or eye; mouth nearly horizontal, with the lower jaw very slightly the shorter; teeth in villiform bands on jaws, vomer, and palatines; gill rakers 8 or 9 + 20 or 21 on first arch, rather long and slender; barbels reach nearly to vertical edge of opercle; both inferior and posterior edges of preopercle entire; opercle armed with two spines at its hind border; least depth of caudal peduncle 2.5 to 2.8 times in length of head; preorbital partially naked, rest of head completely scaled.

First dorsal spine minute, second highest and contained 4 to 4.3 times in length of body or 1.2 to 1.4 times in that of head; first rays of soft dorsal and anal of the same height, each

1.7 to 2.2 times in head; pectoral 3.8 to 4.2 times in length of body; ventral is shorter than pectoral, 5 to 5.6 times in length of body or 1.6 to 1.7 times in that of head, and reaches halfway between its origin and middle of base of anal; the deeply forked caudal slightly shorter than head, 3.2 to 3.4 times in length of body.

Color in life pinkish above, silvery below lateral line, and yellow on ventral surfaces; a bright yellow line from eye to caudal and another from axil of pectoral to caudal; the spinous dorsal is rather broadly tipped with black and has two dusky longitudinal bands; the soft dorsal is edged with dusky and has two or three longitudinal lines of the same color; caudal tipped with dusky; anal and ventrals washed with yellowish. Young specimens bluish above and yellowish on sides, with dusky pectoral and caudal; ventrals and anal lightly washed with yellowish; dorsals longitudinally barred with blackish, the former having a dense black top; a pinkish wash above opercle; barbels dusky in color.

Alcoholic specimens gayish above with darker edges to the scales, yellowish below; traces of longitudinal stripes on upper portions of body; spinous dorsal yellowish to whitish with three longitudinal bands, upper one marginal and dense black; the second dorsal is edged above with blackish and has one or more rather indistinct longitudinal stripes of like color; the caudal fin has a black white-edged margin, which is more conspicuous on lower lobe; pectoral almost transparent, ventral and anal yellowish.

This small species is abundant throughout the Philippines. Our description is based upon the following specimens, ranging from 53 to 137 millimeters in length:

Vigan, Ilocos Sur, 1.
Damortis and Rabon, La Union, 9.
Alaminos, Pangasinan, 2.
Iba, Zambales, 1.
Orani, Bataan, 1.
Manila, 9.
Malabon and Pasay, Rizal, 3.
Cavite, Cavite, 1.
Manila Bay between Cavite and San Nicolas, 2.
San Miguel Bay, 12.
Bacon, Sorsogon, 1.
Mangarin, Mindoro, 8.
Capiz, Estancia, and Iloilo, Panay, 7.
Guinobatan, Masbate, 1.
Borongan, Samar, 15.
San Juanico Strait, 2.
Tacloban, Leyte, 2.
Tagbilaran and Loay, Bohol, 4.
Panacan, Palawan, 1.
Butuan Bay, Agusan River, Gingoog, and Zamboanga, Mindanao, 14.
Sandakan, Borneo, 1.

Four of these specimens, 70 to 112 millimeters in length, collected in 1904, May and June, 1907, and November 20, 1926, are females nearly ready to spawn.

Jordan and Seale had specimens from Cavite; Evermann and Seale from San Fabian, Pangasinan; and Jordan and Richardson from Manila. Seale had specimens from Sandakan, Borneo, and from Hongkong.

This species was originally described from the Strait of Sunda, and ranges from the coast of Hindustan throughout the East Indies eastward to the New Hebrides and north to China and Nagasaki, Japan.

UPENEOIDES VITTATUS (Forskål). Plate 4, fig. 1.

Mullus vittatus FORSKÅL, Descr. Anim. (1775) 31; LACÉPÈDE, Hist. Nat. Poiss. 3 (1798) 382, 401, pl. 14, fig. 1; SHAW, Gen. Zool. 4 (1800) 616, pl. 89.

Upeneus vittatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 329; SMITH and SEALE, Proc. Biol. Soc. Washington 19 (1906) 78; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 273; SEALE, Occ. Papers Bishop Mus. 4 (1906) 51; STEINDACHNER, Sitz. Akad. Wiss. Wien. 115[1] (1906) 1385; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 245.

Upeneoides vittatus BLEEKER, Verh. Bat. Gen. 22 (1849) Perc., 63 ex parte; Act. Soc. Sci. Indo-Neerl. 2 (1857) Achtste Bijdr. Vischf. Amboina, 42; GÜNTHER, Cat. Fishes 1 (1859) 397; KLUNZINGER, Verh. Zool. Bot. Gessell. Wien 20 (1870) 742; GÜNTHER, Fische der Südsee 1 (1873) 55; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 7; DAY, Fishes of India (1878) 120, pl. 30, fig. 2; BLEEKER, Atlas Ichth. 9 (1878) pl. 392, fig. 3; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260.

Upeneoides philippinus FOWLER, Proc. Acad. Nat. Sci. Phila. 70 (1918) 37, fig. 15.

Mullus bandi SHAW, Gen. Zool. 4 (1800) 615.

Bandi goolivindi RUSSELL, Fishes Coromandel 2 (1803) 43, fig. 158.

Dorsal VII–I, 8; anal I, 6; scales $2\frac{1}{2}$–35–$6\frac{1}{2}$.

Greatest depth of body at base of spinous dorsal, 3.7 to 3.9 times in length; head 3.3 to 3.5 times in length; interorbital space nearly flat, its least width 3.5 to 3.8 times in length of head; eye rather large, almost on a line with upper profile of head, 3.7 to 4 times in head; snout moderately short, 2.4 to 2.6 times in length of head or 1.4 to 1.6 times eye, its upper profile very steep anteriorly; the maxillary is broadest posteriorly, equal to snout and reaches below anterior half of pupil; mouth almost horizontal, with jaws almost even; teeth villiform, in bands on jaws, vomer, and palate; first arch containing 7 or

8 + 17 to 20 moderately long and slender gill rakers; the barbels extend to the vertical from angle of the smooth preopercle, 1.7 to 1.9 times in head; two spines at hind edge of opercle, the upper smaller and hidden under a scale; least depth of caudal peduncle nearly equal to length of snout or maxillary, 2.5 to 2.8 times in head; no scales on preorbital, rest of head completely covered with ctenoid scales.

Third dorsal spine the highest, 1.3 to 1.4 times in head and slightly higher than the one preceding, first spine minute and inconspicuous; second dorsal and anal equal in height, 2 to 2.1 times in head; pectoral 1.3 to 1.5 times in length of head, longer than ventral which extends to below vertical from axil of first dorsal fin; caudal deeply forked, very slightly shorter than head, 3.4 to 3.8 times in length of body.

The color in life of several specimens was as follows:

A specimen from Bantayan Island was brownish above, yellowish below, belly bright yellow, with two bright yellow longitudinal lines on sides and three darker ones above them; the two dorsals were black at top, with two dusky longitudinal bands through each fin; the caudal was yellowish with four or five oblique black bands on upper lobe, and three or four on lower; the last band on lower lobe was at tip, the second one from it broader than the rest; pectoral, ventrals, and anal uniformly yellowish.

Two examples from Sandakan, Borneo, were dull brownish silvery; there were four or five yellow longitudinal lines on each side of body; a black tip to spinous dorsal, a dusky longitudinal band through its middle, and a third one of like color near base; the soft dorsal had three dusky longitudinal bands; the caudal had five oblique black bands on upper lobe, and four on lower; the penultimate black band was wider than the rest.

Four specimens from Guam were pinkish yellow in life, with four dark yellow longitudinal lines on sides; the spinous dorsal with a large black tip, a rather wide black band through center, and a narrower one at base of fin; second dorsal had three rather faint dusky longitudinal bands; upper lobe of caudal had five oblique black bands, lower one four, the second from the last the widest. In the young all the color markings, excepting the bars on the fins, were usually absent.

In alcohol the ground color is slightly grayish above and yellowish below, with traces of the yellow longitudinal bands on sides; spinous dorsal black at top and barred longitudinally with dusky at its middle and base; the rayed dorsal has three

dusky longitudinal bands the last one on the top; the caudal has four or five oblique black bands on its upper lobe, the lower three or four; the last black band of lower lobe or the one next to it usually broader than the rest; the other fins unmarked.

The above account is taken from seventy-six specimens, varying from 27 to 171 millimeters in length, taken at the following localities:

Aparri, Cagayan, 2.
Bangui, Ilocos Norte, 1.
Damortis and Rabon, La Union, 3.
Alaminos, Pangasinan, 2.
Iba, Zambales, 2.
Orani, Bataan, 1.
Pasay, Rizal, 1.
Manila, 1.
Nasugbu, Batangas, 1.
Puerto Galera and Mangarin, Mindoro, 3.
Borongan, Samar, 1.
New Washington and Capiz, Capiz Province, 10.
Bantayan Island, 1.
Iloilo, Iloilo, 1.
Cebu, Cebu, 2.
Tagbilaran and Loay, Bohol, 5.
Dumaguete, Oriental Negros, 1.
Agusan River, Mindanao, 1.
Cagayan de Misamis, 14.
Balabac Island, 3.
Davao, Davao, 1,
Zamboanga, Zamboanga, 5.
Southern coast of Cotabato Province, 4.
Jolo Island, 4.
Sandakan, Borneo, 2.
Guam, 4.

Günther had specimens from "the Philippines;" Smith and Seale's specimens came from the Rio Grande, Cotabato Province, Mindanao, and Seale and Bean's from Zamboanga, Mindanao; Jordan and Richardson recorded this species from Lubang Island and from Iloilo. Fowler's *U. philippinus* from the "Philippine Islands" does not seem different to us.

This species reaches a length of over 300 millimeters; it is common from the Red Sea and the east coast of Africa through the Indian Ocean and the East Indies on throughout Polynesia to Tahiti and the far-off Marquesas; it occurs northward to Kagoshima Bay, Japan.

Genus UPENEUS Cuvier

Upeneus CUVIER, Regne Anim. ed. 2 2 (1829) about 160; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 428.
Pseudupeneus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 14 (1862) 134.
Parupeneus BLEEKER, Verh. Natuurk. Akad. Kon. Amsterdam 15 (1875) Révis. Mulloides 17.

This genus is separated from the rest of the goatfishes by the presence of but one row of teeth in the jaws, while the roof of the mouth is toothless. Dorsal spines VIII.

Body oblong or elongate, compressed laterally, head often large; the nearly horizontal mouth low, the jaws equal or nearly

so, with thick lips; opercle armed with a spine on its posterior border, sometimes with two; interorbital space concave, narrow; barbels usually long, often nearly as long as head; scales very large, head covered with large scales; the bone forming a hook over maxillary is less developed than in *Mullus;* caudal fin forked.

This genus includes many species in tropical seas, many of them important food fishes. We recognize twelve species in our Philippine material. We have included *U. macronemus* in our key, as there is little doubt of its occurrence in the Philippines, though we have obtained no specimen.

Key to the Philippine species of Upeneus.

a^1. Barbels not extending beyond posterior margin of preopercle; a round black spot at caudal base.

b^1. A wide black stripe from snout through eye to below soft dorsal; a yellow stripe usually above it; one opercular spine. **U. barberinus.**

b^2. A broad yellow or pale saddle before the black blotch on caudal peduncle; a reddish or pale line from snout along upper margin of eye to soft dorsal, and another along lower margin to below second dorsal, the region between a more or less dusky band; two opercular spines..... **U. dispilurus.**

a^2. Barbels extending beyond posterior edge of preopercle.

c^1. Barbels not reaching beyond posterior margin of opercle.

d^1. No black spots or bands anywhere; color uniform yellowish or a golden spot on each scale of body..... **U. luteus.**

d^2. Body with black spots, blotches, or crossbands.

e^1. A rounded black spot at base of caudal or on side of caudal peduncle.

f^1. A black band from tip of snout through eye to below middle of second dorsal; large lateral black spot on anterior part of caudal peduncle..... **[U. macronemus.]**

f^2. No longitudinal black band through eye.

g^1. A yellow spot on lateral line below posterior half of first and anterior part of second dorsal..... **U. indicus.**

g^2. Red in life with three curved olive stripes from tip of snout to below soft dorsal, the middle one through eye; caudal peduncle with a blackish saddle, darker below and forming a round black spot on side; color uniform in alcohol, with a black spot on caudal peduncle. **U. spilurus.**

e^2. No black spot on caudal peduncle.

h^1. Body with three wide blackish crossbands, first below anterior part of spinous dorsal, second below solft dorsal, third on posterior half of caudal peduncle..... **U. bifasciatus.**

h^2. Body not crossbanded with black or dusky, but with a black spot or blotch on lateral line.

i^2. A large black area on anterior part of body with a black line from its upper part through eye to tip of snout; black lateral spot below posterior rays of second dorsal. **U. barberinoides.**

i^2. The black lateral blotch between two dorsals, with a larger oblong yellow area behind it..... **U. pleurostigma.**

c^2. Barbels reaching or almost reaching base of ventrals.

j^1. Color uniform, no markings on fins or body..... **U. cyclostomus.**

j^2. Color not uniform.

k^1. Body with four or five blackish crossbands; a broad yellow area between the black band below soft dorsal and the black saddle on caudal peduncle..... **U. moana.**

k^2. Body not crossbanded with blackish.

l^1. A yellow or whitish saddle on caudal peduncle behind soft dorsal; color usually livid purplish..... **U. chryserydros.**

l^2. No yellow area anywhere; a black spot between lateral line and posterior half of pectoral; head and snout with three pearly bluish longitudinal bands; soft dorsal, anal, and caudal barred with brown..... **U. pleurospilos.**

UPENEUS BARBERINUS (Lacépède). Plate 3, fig. 3.

Mullus barberinus LACÉPÈDE, Hist. Nat. Poiss. 3 (1798) 406, pl. 13, fig. 3.

Upeneus barberinus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 340; GÜNTHER, Cat. Fishes 1 (1859) 405; KNER, Reise Novara, Fische (1865) 70; KLUNZINGER, Verh. Zool. Bot. Gessell. Wien 20 (1870) 545; GÜNTHER, Fische der Südsee 1 (1873) 57, pl. 42; DAY, Fishes of India (1878) 124; MEYER, Ann., Soc. Esp. Hist. Nat. 14 (1885) 16; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260; SEALE and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 44.

Parupeneus barberinus BLEEKER, Ned. Tijds. Dierk. 1 (1863) 234; Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 25; Atlas Ichth. 9 (1878) pl. 393, fig. 1; WEBER, Fische, Siboga Exp. (1913) 296.

Pseudupeneus barberinus JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 782; SEALE, Occ. Papers Bishop Mus. 4 (1906) 49; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 276; Bull. Bur. Fisheries 26 (1907) 25; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Local name at Cuyo, *amakan.*

Dorsal VIII–I, 9; anal I, 6; scales $2\frac{1}{2}$–28 + 2–$5\frac{1}{2}$.

Body rather deep, its greatest depth at origin and anterior part of spinous dorsal, 3.1 to 3.7 times in length; the pointed head much longer than deep, 2.7 to 3.1 times in total length; interorbital space moderately convex, its least width 3.8 to 4.2 times in head; the moderately small eye much nearer posterior margin of opercle than tip of snout and entirely in second half

of head, 4.8 to 6.5 times in head or 2.5 to 4 times in snout; the long pointed snout 1.6 to 1.9 times in head and the much shorter maxillary 2.7 to 3.1 times, the latter extending nearly halfway between end of snout and vertical from hind border of eye; jaws about even, each with a single series of conical, moderate, rather widely spaced teeth; there are 6 (rarely 7) + 21 to 23 gill rakers on first arch; the long barbels are 1.3 to 1.6 times in head and just touch the vertical edge of the smooth preopercle; opercle armed with a single spine at its hind edge; least depth of caudal peduncle 2.5 to 3.1 times in head; scales large, finely and weakly ctenoid, absent on preorbital.

Third dorsal spine the highest, 1.4 to 1.8 times in head, second a little lower, and first minute; second dorsal and anal about the same height, 2.3 to 2.8 times in head, their last rays not much produced and equal to or much lower than anterior rays; pectoral nearly as long as ventral which is contained 1.3 to 1.6 times in head, the latter reaching the vertical midway between dorsals; caudal fin shorter than head, 3.2 to 3.5 times in length.

Some of the specimens were silvery in life, washed with yellowish or pink; they had a distinct black line from below second dorsal through eye to end of snout; a rounded black spot was present on middle of root of caudal fin.

Other examples were pinkish white, brownish on the nuchal region and on top of head; a wide deep black stripe from tip of snout through eye to below middle of soft dorsal; just above this black band was a deep yellow stripe, broadest at the center, extending from eye to below second dorsal; a round black spot at base of caudal fin; the first dorsal was bluish white, indistinctly blotched with vinous red; the soft dorsal was bluish, with a vinous blotch extending to tips of membranes; the caudal and the ventral were pinkish, the latter red at axil.

Still other specimens were pinkish white, with a black stripe from tip of snout to below soft dorsal and a round black spot near base of caudal fin; just above the black longitudinal stripe was a golden band extending from behind eye to below anterior half of second dorsal; both dorsal fins were pink.

In alcohol the ground color is yellowish to yellowish brown, darker along back; a wide black stripe runs longitudinally from tip of snout through eye to below soft dorsal, and there is only a trace of the yellow band from behind eye to about where the black band ends posteriorly, or it may be altogether absent;

a rounded black spot at middle of posterior end of caudal peduncle; all the fins are yellowish to whitish.

We have examined one hundred nine specimens of this species in the Bureau of Science collection, ranging from 21.5 to 280 millimeters in length, from the following localities:

Luna and Balaoan, 7.
Subic Bay, 1.
Manila, 12.
Puerto Galera and San Jose, Mindoro, 26.
Bacon, Sorsogon, 1.
Tablas Island, 2.
Bantayan Island, 3.
Agutaya Island, 1.
Tacloban, Leyte, 1.
Cuyo Island, 5.
Cebu, Cebu, 2.
Negros, 1.
Canigaran and Puerto Princesa, Palawan, 14.
Tagbilaran, Bohol, 2.
Dumaguete, Oriental Negros, 5.
Surigao, Surigao, 2.
Cagayan de Misamis, 3.
Balabac Island, 9.
Davao, Mindanao, 2.
Caldera Bay and Zamboanga, Mindanao, 3.
Tubigan, Jolo, Bungau, and Sibutu Islands, Sulu Archipelago, 7.

In this fish the last rays of the second dorsal and of the anal are not prolonged, as in *Upeneus macronemus* (Lacépède), in which they are much longer than the other rays. The rounded black spot in the latter is more anterior, located about midway in the length of the caudal peduncle, whereas in *U. barberinus* it immediately precedes the base of the caudal fin. Some of our specimens are very close to *U. macronemus*, but we have seen none that is unquestionably of that species.

Since writing the above we have received two very fine specimens from the Cuyo Islands, 360 and 390 millimeters long, the latter 485 millimeters, including the caudal fin. They are noticeable particularly for the elongation of the first dorsal, particularly of the second spine, which extends to or beyond the middle of the base of the second dorsal when depressed. In specimens of this size the eye is noticeably small in proportion to the head and snout.

This fine food fish is one of the largest goatfishes, and reaches a length of a little more than half a meter. It is common from the Red Sea eastward to the Pelew, Society, and Austral Islands, and all intervening islands.

UPENEUS DISPILURUS Playfair. Plate 3, fig. 2.

Mullus dispilurus PLAYFAIR, Fishes of Zanzibar (1866) 41, pl. 5, fig. 3.
Upeneus dispilurus DAY, Fishes of India (1878) 125, pl. 31, fig. 3.
Mullus pleurotaenia PLAYFAIR, Fishes of Zanzibar (1866) 41, pl. 5, fig. 4.

Upeneus pleurotaenia SNYDER, Proc. U. S. Nat. Mus. 42 (1912) 501; JORDAN and HUBBS, Mem. Carnegie Mus. 10 (1925) 246.
Pseudupeneus ischyrus SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 90, fig. 2.
Upeneus ischyrus JORDAN, TANAKA, and SNYDER, Journ. Coll. Sci. Imp. Univ. Tokyo 33 (1913) 183, fig. 133.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–28 + 2–$6\frac{1}{2}$.

Body markedly deep, its greatest depth at origin of spinous dorsal, 3.3 times in length, upper outline strongly elevated; head slightly longer than deep, 3 times in length; the evenly convex interorbital 3.2 times in head, much wider than eye which is contained 4.9 times; snout twice in head and more than twice eye, its upper profile almost straight; maxillary is 2.6 times in head and extends almost to below anterior nostril; jaws even, with rather thick lips; teeth conical and bluntish, rather thick lips; teeth conical and bluntish, rather stout and widely spaced, in a single row in both jaws; 7 + 22 gill rakers on first arch, the longest hardly half eye; the barbels are contained 1.5 times in head and reach below hind margin of the smooth preopercle; two opercular spines, the upper much the smaller; least depth of caudal peduncle equals length of maxillary; scales large and finely ctenoid; head completely scaled.

Third dorsal spine the highest, 1.6 times in head, the first one very small; second dorsal slightly higher than anal, 2.3 times in head; pectoral a trifle shorter than ventral, which is 1.3 times in head or 4 times in length of body and extends nearly to anus; caudal slightly shorter than head, 3.2 times in length of body.

An example from Zamboanga was yellowish white in life, with a blackish line from tip of snout through eye, fading out on lateral line above extremity of pectoral; above and below this black behind eye were a number of fine bright yellow lines; there was a large black blotch on caudal peduncle, almost entirely above lateral line and connected indistinctly with its fellow on the opposite side by a dusky area over the back; in front of the black blotch was a large yellowish saddle.

Another specimen from the same locality was reddish above, overlaid with brown and yellow; a pink line from upper posterior margin of eye to middle of base of soft dorsal; another line, rather wide and almost white, ran longitudinally from lower margin of eye, fading out near the board yellow saddle over caudal peduncle; there was a third pinkish line from distal half

of maxillary to lower half of base of caudal, this line similar to belly in color and separated from it by an irregular wide yellowish area; behind the yellowish saddle on caudal peduncle was a large rounded black spot, entirely above lateral line but not connected above with its fellow; the dorsal spines were pink, the membranes yellow, the soft dorsal was pink, longitudinally bared with yellow; the anal was colored similarly to the second dorsal; the caudal, ventrals, and pectoral were pink.

A fresh specimen from Manila was colored as follows: The trunk pinkish white below the lateral line, pinkish above, the scales on upper half edged with brownish orange, imparting a dusky hue, the scales on lower part of body edged with orange; head pink to coral red; a wide bright coral red band extends from tip of snout backward over upper margin of eye to posterior part of base of second dorsal, gradually becoming pale pink posteriorly; a similar broad band extends from snout along lower margin of eye, terminating on side beneath origin of second dorsal, just after crossing lateral line; behind eye this second band rapidly becomes paler, changing to pink and then to pinkish white; behind eye the region between these two bands appeared as a rather dusky stripe; on the back of caudal peduncle immediately behind second dorsal is a bright pinkish white spot, followed by a rather dusky or deep brown saddle; dorsals and caudal deep coral red, first dorsal sprinkled over its middle and posterior part with pearly bluish white spots, second dorsal with some pink spots and a pink marginal band posteriorly; pectoral, ventral, and anal orange, pectoral unmarked, ventral edged anteriorly with pearl white, and anal with four longitudinal rows of pearl white spots.

In alcohol the ground color of the first specimen is deep yellowish brown and yellowish below; a yellow longitudinal band runs from lower edge of preorbital to the well-pronounced yellow saddle on caudal peduncle, broadly bordered above and below by two deep brown bands, the upper one from tip of snout through eye to the base of the rayed dorsal, and the lower from posterior end of maxillary, fading on lateral line under the black blotch on caudal peduncle.

Here described from three specimens, 98 to 260 millimeters long, collected at Manila; Calapan, Mindoro; and Zamboanga, Mindanao. The other Zamboanga specimen referred to above is not now in the collection.

Playfair described this species from specimens from the islands of Zanzibar and Pemba, on the east coast of Africa Snyder had a specimen from Tokyo, and later specimens from Naha and Okinawa, Japan. Jordan had a specimen from Kagoshima, obtained at Hongkong by Walter Fong. It is evidently a rare species, though widely distributed.

This species is close to *Upeneus signatus* Günther, from Port Jackson, Australia. As Day pointed out in the Fishes of India, *dispilurus* and *pleurotaenia* are merely the adult and young of the same fish. Our specimens are like Playfair's figure of *dispilurus*.

UPENEUS LUTEUS Cuvier and Valenciennes. Plate 5, fig. 1.

Upeneus luteus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 392; BLEEKER, Verh. Bat. Gen. 22 (1849) 63; DAY, Fishes of India (1878) 125, pl. 31, fig. 2; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 87.

Mullus luteus PLAYFAIR, Fishes of Zanzibar (1866) 41.

Pseudupeneus luteus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 89.

Parupeneus luteus BLEEKER, Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 32; Atlas Ichth. 9 (1878) pl. 394, fig. 1; KLUZINGER, Fische des Rothen Meeres (1884) 52; WEBER, Fische, Siboga Exp. (1913) 296.

Upeneus cyclostoma GÜNTHER, Cat. Fishes 1 (1859) 409 (not of Cuvier and Valenciennes).

Dorsal VIII–I, 9; anal I, 6; scales $2\frac{1}{2}$–26 + 3–$6\frac{1}{2}$.

The notably deep body is deepest at origin and along base of first dorsal, its upper profile strongly and evenly curved from tip of snout to origin of second dorsal, the greatest depth 3.3 to 3.4 times in length; head not much longer than deep, 3 to 3.1 times in length of body; the moderately convex interorbital 3.4 to 3.5 times in head; eye moderate, a little nearer posterior edge of opercle than tip of snout, 4.6 to 4.7 times in head; the moderate snout more than twice eye and 1.8 to 2 times in head; maxillary is 2.5 times in head and extends to almost below posterior nostril; mouth nearly horizontal, with even jaws; a row of conical, rather widely spaced teeth in each jaw; 6 + 19 to 21 slender gill rakers on first arch, the longest very slightly more than half eye; the long and slender barbels are 3.7 to 3.8 times in length of body and reach nearly to posterior edge of opercle, which is armed with a sharp-pointed, rather long spine on its hind border; least depth of caudal peduncle 2.7 to 3 times in head; scales large and finely ctenoid, present all over head excepting on preorbital.

Second and third dorsal spines equal, higher than the rest, 1.5 to 1.6 times in head; first spine very small; second dorsal as high as anal, 2.5 to 2.7 times in head; pectoral 4 times in head, longer than ventral which extends to a perpendicular halfway between dorsal; caudal fin equals head, its upper lobe slightly the longer.

A single specimen from Zamboanga was pinkish above in life, with several rather indistinct bluish lines on each side of head and body; the scales on body were each obscurely spotted with golden; all the fins were pinkish.

The ground color in alcohol of body and fins is uniformly yellowish brown, with no visible markings of any kind.

Here described from an example, 155 millimeters long, from Dumaguete, Oriental Negros, and one, 173 millimeters in length, from Zamboanga, Mindanao. Evermann and Seale had a specimen from Jolo and Weber had one also from the Sulu Archipelago.

This species is well distinguished by its deep body, the evenly well-rounded upper profile of head, and the longer upper lobe of caudal. It ranges from the Red Sea and Zanzibar through the East Indies to the Louisade Archipelago, off the southeast end of New Guinea. It attains a length of more than 300 millimeters.

UPENEUS INDICUS (Shaw). Plate 2, fig. 1.

Mullus indicus SHAW, Zoölogy 4 [2] (1800) 614.

Upeneus indicus GÜNTHER, Cat. Fishes 1 (1859) 406; DAY, Fishes of India (1878) 126, pl. 31, fig. 4.

Pseudupeneus indicus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907); EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88; SNYDER. Proc. U. S. Nat. Mus. 32 (1907) 93.

Parupeneus indicus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 28; Atlas Ichth. 9 (1878) pl. 394, fig. 5; WEBER, Fische, Siboga Exp. (1913) 296.

Upeneus russelli CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 342.

Upeneus waigiensis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 343.

Upeneus malabaricus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 344; GÜNTHER, Cat. Fishes 1 (1859) 407; Fische der Südsee 1 (1873) 58 pl. 45, fig. B; WEBER, Fische, Siboga Exp. (1913) 297.

Upeneus griseofrenatus KNER, Sitz. Akad. Wiss. Wien. 58 (1868) 305, pl. 3, fig. 7.

Dorsal VIII–I, 8; anal I, 7; scales $2\frac{1}{2}$–28 or 29–$6\frac{1}{2}$.

Body deepest at origin and anterior part of first dorsal, depth 3.4 to 3.6 times, head 2.9 to 3.2 times in length; interorbital

space evenly and slightly convex, its least width 3.6 to 4.2 times in head; the rather small eye nearly in middle of head in younger specimens, in older ones partly or entirely in posterior half, 4.4 to 5.5 times in head; snout somewhat pointed and elongate, 1.7 to 2 times in head or 2.3 to 3.1 times eye, its upper profile nearly straight, maxillary widest posteriorly, 1.5 to 1.7 times in snout; jaws equal; teeth conical and bluntish, widely spaced, in a single series in each jaw; first gill arch has 4 or 5 + 19 or 20 gill rakers, the longest about half eye; the long slender barbels reach slightly beyond angle of the smooth preopercle and are contained 1.3 to 1.4 times in head; opercle armed at its hind edge with a spine; least depth of caudal peduncle 2.4 to 2.8 times in head; scales finely ctenoid, extending on top of head to tip of snout, entire head scaly except preorbital.

First dorsal spine minute, third one highest, 1.5 to 1.7 times in head, only slightly higher than fourth; second dorsal slightly higher than anal, 2 to 2.3 times in head; pectoral about as long as barbel, ventral 1.2 to 1.5 times in head and extending to below axil of first dorsal; the deeply forked caudal a little shorter than head, 3.1 to 3.5 times in length of body.

The ground color in life is yellowish or olive green, each scale with a darker margin; a large ovate or oblong, rather elongate, bright golden yellow blotch on lateral line below posterior half of first dorsal and anterior portion of second; a large rounded black spot on lateral line before base of caudal fin; soft dorsal and anal yellowish, longitudinally barred with three to five pale blue stripes; the other fins of the same color, unmarked; each side of head has several longitudinal bluish streaks or yellowish blue margined stripes radiating from eye, the lower ones running lengthwise below eye, the barbels pinkish.

Living specimens at Calapan, Mindoro, had the head yellowish, the body pale, the scales edged with gold; posteriorly each scale with a bluish pearly spot, or some specimens with a violet spot on each scale, the lower part of body roseate; a large black spot on middle of caudal peduncle, above lateral line; a large elongate golden spot on side below posterior part of first dorsal and extending to below origin of second dorsal; two bright blue longitudinal lines on cheek and blue crosslines on occiput; several blue lines running downward on opercle; pectoral pink, the other fins golden violet; anal with two longitudinal blue lines; barbels dirty flesh color.

Alcoholic specimens are brownish to dusky above and yellowish brown below, with darker edges to the scales; an oblong yellow

spot on lateral line above posterior half of pectoral and a blackish rounded blotch on each side of caudal peduncle; traces of longitudinal bluish streaks on dorsal rays, none on anal fin; the lines on head have faded.

We have examined forty-six specimens in the Bureau of Science collection, ranging from 59 to 285 millimeters in length. They were taken at the following localities:

Luna and Balaoan, La Union, 3.
Subic Bay, 4.
Calapan and Pinamalayan, Mindoro, 22.
Bacon, Sorsogon, 2.
Tacloban, Leyte, 1.
Bantayan Island, 2.
Cebu, Cebu, 3.
Puerto Princesa, Palawan, 2.
San Juan, Siquijor Island, 2.
Cagayan de Misamis, Mindanao, 1.
Zamboanga, Mindanao, 3.
Jolo, Sulu Province, 1.

Three of these are ripe females, 144 to 162 millimeters long, collected in February, April, and August, 1908.

Jordan and Seale had specimens from Iloilo, and Evermann and Seale from Bacon and Bulan, Sorsogon.

We agree with Bleeker, Day, and Snyder in uniting *U. malabaricus* with *U. indicus*. This species has an enormous range, occurring from Zanzibar on the east coast of Africa to Samoa and the Tonga Islands, far to the southeast in Polynesia, northward to Formosa, the Riu Kiu Islands, and southern Japan. It is an excellent food fish, and reaches a length of over 400 millimeters.

UPENEUS SPILURUS Bleeker.

Upeneus spilurus BLEEKER, Nat. Tijds. Ned. Ind. 6 (1854) 395; Verh. Bat. Gen. 26 (1854–1857) 68, pl. 2, fig. 2; GÜNTHER, Cat. Fishes 1 (1859) 406; SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 91.

Parupeneus spilurus BLEEKER, Arch. Neerl. Sci. Nat. 13 (1878) 63; Natuurk. Verh. Kon. Akad. Amsterdam 18 (1879) 10.

Pseudupeneus spilurus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Dorsal VIII–I, 8 or 9; anal II, 6 or 7; scales 2–28 or 29–6.

Depth of the oblong compressed body 3 times, head 3.2 times in length; dorsal outline strongly arched; depth of head 1.25 to 1.33 times in its own length; the long-pointed snout twice in head, its dorsal outline concave; interorbital space usually very convex, occasionally somewhat flattened, its width 3 times in head; eye 4 to 5.5 times in head; lower jaw slightly shorter than upper, lips very broad, upper partly covering anterior edge of the fleshy maxillary, which is 2.6 times in head, its upper edge largely covered by preorbital; jaws with a single row of 16 to 20 widely spaced stout teeth; the barbels extend to operculum

or beyond; opercle with a sharp spine; head completely scaled, the scales on snout, maxillary, and chin deeply embedded and sometimes not visible; first dorsal spine very short, closely adnate to second; third and fourth spines longest, 1.6 times in head, extending beyond tips of other spines when fin is depressed; the longest soft dorsal ray 1.5 times in head, anal slightly lower than soft dorsal; caudal deeply divided, with pointed lobes, 1.875 times in head; pectorals and ventrals pointed, about 1.4 times in head; depth of caudal peduncle 8 times in length; lateral line arborescent; pseudobranchiæ large; gill rakers 6 + 23, slender, the longest equal to eye; peritoneum silvery; air bladder large.

Color in life bright carmine red, with three curved olive stripes, with a brassy sheen, extending from tip of snout to below end of soft dorsal, the median stripe passing through eye and along lateral line; caudal peduncle with a blackish saddle, the lower portions darker, forming a round black spot on each side of tail; two round dusky spots behind eye; fins pink, the pectorals and spinous dorsal darker than others; ventrals with indistinct basal and subterminal dark bands.

In alcohol the bright colors fade. Bleeker gives the color as violaceous rose on back and snout, rosy on sides, yellowish rose on belly; he does not mention longitudinal stripes, but does mention a violet-black spot on each side of tail above lateral line.

Evermann and Seale had a specimen, 100 millimeters long, from Bulan, Sorsogon. Bleeker described this species from one example, 160 millimeters long, from Nagasaki. Later he had one from New Guinea. Snyder had a number of specimens from Wakanoura and Nagasaki. He states that this species is rare and reaches a length of about 300 millimeters.

UPENEUS BIFASCIATUS (Lacépède). Plate 6, fig. 2.

Mullus bifasciatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 14, fig. 2.

Upeneus bifasciatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 344; GÜNTHER, Fische der Südsee 1 (1873) 59, pl. 44, fig. A; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88.

Pseudupeneus bifasciatus JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 258, fig. 107; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 274.

Mullus trifasciatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 15, fig. 1.

Parupeneus trifasciatus WEBER, Fische, Siboga Exp. (1913) 295.

Dorsal VIII–9; anal I, 6; scales 2–28–6.

Body notably deep, the greatest depth at base of anterior dorsal spines, 3 to 3.2 times in length, the dorsal contour rather strongly arched anteriorly; the deep head equals depth of body; interorbital space very convex, its least width 3.3 to 3.7 times in head; eye fairly large, 4.2 to 4.3 times in head; the moderate snout 1.7 to 1.9 times in head or 2.2 to 2.5 times eye; the maxillary is very broad posteriorly and extends more than two-thirds the distance to anterior margin of orbit; jaws equal, lips thick and broad; a single row of rather bluntish conical teeth in each jaw; first gill arch contains 8 + 27 or 28 gill rakers; the barbels extend to slightly behind posterior edge of preopercle, each 1.6 to 1.7 times in head or 4.8 to 5.4 times in length of body; the preopercle edges entire and the opercle armed with two spines at its hind border; least depth of caudal peduncle 2.4 times in head.

Lips and preorbital bones naked, other parts of head, including maxillary, scaled; third spine of first dorsal the highest, 1.5 to 1.6 times in head; second ray of dorsal and anal highest, that of latter fin slightly the higher, 2.2 to 2.4 times in head; pectoral 1.2 to 1.4 times in head and shorter than ventral which reaches anal opening; the moderately forked caudal about as long as head, 3.1 to 3.2 times in length of body.

In life the general color is pinkish white with three wide blackish crossbands on each side extending down to middle of body, the first from anterior third of spinous dorsal, the second from entire base of soft dorsal, the third covering posterior half of caudal peduncle; the scales on the spaces between these bands edged with golden; top of head and snout drab; three whitish violet lines across preorbital; preopercle and lower portions of opercle lightly washed with reddish; spinous dorsal reddish, slightly washed with yellow on some of the membranes; soft dorsal dusky red at base, its outer portion with longitudinal lines of alternating yellow and bluish; the anal fin has longitudinal lines of alternating bluish and yellow; pectoral fin pinkish; rays of caudal yellow, membranous portions grayish; ventral reddish with membranes yellow; pectoral pinkish, with a reddish bar at its base.

Ground color in alcohol yellowish to yellowish brown; two wide blackish crossbands on each side of trunk, one below each dorsal fin; a third blackish band covers posterior half of

caudal peduncle; a small blotch of like color behind each eye; second dorsal blackish near base and with blackish longitudinally on its upper portion; anal banded longitudinally with blackish; pectoral and spinous dorsal yellowish, the former having a blackish spot at its axil; ventral yellowish, with the spine blackish; caudal fin yellowish to slightly grayish.

This species, which has been reported previously from Bacon, Sorsogon, by Evermann and Seale, is here described from four examples, 43 to 192 millimeters long, coming from Luna, La Union; Cabusao, Camarines Sur; Zamboanga; and the southern coast of Cotabato Province, Mindanao. Weber had a specimen, 195 millimeters long, from Sulu.

This excellent food fish reaches a length of 300 millimeters or more, and is abundant at Hawaii and Samoa. It is found from Marcus Island at the northwest, through the Caroline and Solomon Islands to Raratonga. It was originally described from Réunion, in the Indian Ocean.

UPENEUS BARBERINOIDES Bleeker. Plate 4, fig. 3.

Upeneus barberinoides BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 263; GÜNTHER, Cat. Fishes 1 (1859) 406.

Parupeneus barberinoides BLEEKER, Ned. Tijds. Dierk. 1 (1863) 234; Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) 22; Atlas Ichth. 9 (1878) pl. 392, fig. 5.

Dorsal VIII–I, 8 or 9; anal I, 6 or 7; scales $2\frac{1}{2}$–28–$6\frac{1}{2}$.

Greatest depth of the body 3.2 to 3.4 times in length, the dorsal contour gently sloping from origin of dorsal to tip of snout; head contained 2.8 to 3 times in length of body; the strongly convex interorbital 3.4 to 3.9 times in head; the moderately small eye 4.5 to 5.1 times in head and 2.5 to 2.8 times in the rather elongate snout, which is 1.8 times in head; the maxillary is 2.6 to 2.9 times in head and reaches about midway between anterior nostril and anterior margin of eye; jaws even, lips rather broad; teeth in each jaw a single row of small, rather bluntish, widely spaced conical teeth; 6 or 7 + 22 to 24 gill rakers on first arch; barbels contained 3.7 to 4 times in length of body, extending beyond posterior edge of the smooth preopercle but not quite reaching base of ventrals; the opercle has two spines at its hind border; least depth of caudal peduncle 2.6 to 2.9 times in head.

Head completely covered with scales; of the fins only the caudal is scaly; third and fourth dorsal spines the highest, each 4.2 to 5.1 times in length of body; the last rays of dorsal and anal are the highest, each 2 to 2.8 times in head; pectoral

slightly shorter than ventral, the latter 1.2 to 1.4 times in head and extending to anus; the deeply forked caudal a little shorter than head, 3.1 to 3.2 times in length of body.

In life this fish is deep red along back of head and body, opercles deep purplish red, preopercles dusky reddish brown; on anterior part of trunk is a large black area, with a black line extending forward from its upper part through eye to tip of snout; a yellow band on posterior part of body below lateral line, ending in a yellow crossbar on base of caudal; a blackish spot on lateral line below posterior dorsal rays; some brilliant pearly bluish spots behind eye and two rows of like spots above lateral line, extending back below anterior part of soft dorsal; on posterior part of trunk are violet spots on the middle scales, back to caudal; a yellowish white band below eye from above upper end of gill opening nearly to angle of maxillary, widest anteriorly; opercles deep purplish red; preopercles dusky reddish brown; breast and belly pinkish to very pale pink; barbels deep red; anterior portion of spinous dorsal deep pink or reddish, posterior region dusky bluish; lower half of soft dorsal dusky blue, outer portion yellow, marked with longitudinal violet lines; the anal has longitudinal stripes of alternating yellow and pale violet; caudal yellow on the rays and reddish on the membranous portions, narrowly edged above with deep red, and broadly margined below with black; ventrals blackish, slightly washed with yellow and reddish; pectoral yellow, streaked on the membranes with reddish, its base with a black bar; a black spot on lateral line below base of posterior rays of second dorsal. Living specimens at Calapan, Mindoro, had a brilliant sapphire spot on each scale above the middle of body, these changing to violet on lower half.

Alcoholic specimens yellowish to dark violet-brown; a lateral blackish band through eye, extending to below the space between first and second dorsal fins and uniting with upper posterior part of the large blackish blotch on each side of body which extends forward to opercles; a blackish spot on lateral line below posterior rays of second dorsal; first dorsal blackish from third to last spine; second dorsal blackish on its lower half and with alternate yellowish and bluish stripes on its upper half; a blackish longitudinal band on the longest rays of lower caudal lobe; the yellowish anal has longitudinal blackish stripes; pectoral yellowish, its base and axil blackish, ventrals almost entirely grayish or blackish.

Here described from twenty-seven examples, 33.5 to 160 millimeters in length, from the following localities: Subic Bay; Puerto Galera and Calapan, Mindoro; Concepcion, Busuanga; Negros; Buenavista, Guimaras; Cebu, Cebu; Zamboanga, Mindanao.

This species, which has not been reported previously from the Philippines, is known only from Ceram, Celebes, Ternate, Amboina, and New Guinea.

UPENEUS PLEUROSTIGMA Bennett. Plate 5, fig. 2.

Upeneus pleurostigma BENNETT, Proc. Zool. Soc. London (1831) 59; GÜNTHER, Fische der Südsee 1 (1873) 58; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 29.

Mullus pleurostigma PLAYFAIR, Fishes of Zanzibar (1866) 40.

Parupeneus pleurostigma BLEEKER, Atlas Ichth. 9 (1878) pl. 393, fig. 3.

Parupeneus pleurostigma STEINDACHNER, Denkschr. Acad. Wiss. Wien 70 (1900) 486.

Pseudupeneus pleurostigma JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1903) 456; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 260, fig. 108.

Upeneus brandesi BLEEKER, Nat. Tijds. Ned. Ind. 2 (1851) 236; GÜNTHER, Cat. Fishes 1 (1859) 407.

Parupeneus brandesi BLEEKER, Ned. Tijds. Dierk. 2 (1865) 281.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–28–$5\frac{1}{2}$.

Body rather deep, its greatest depth about base of anterior dorsal spines, 3.4 to 3.7 times in length; head 3 to 3.2 times in length, its upper outline slightly arched; interorbital space evenly and moderately convex, its least width 3.4 to 3.7 times in head; the rather small eye high up, near upper profile of head, 4.8 to 5.4 times in head; snout 1.7 to 1.8 times eye, pointed and elongate, its upper outline nearly straight; maxillary widest posteriorly, its length 2.4 to 2.6 times in head or 1.3 to 1.5 times in snout; lips thick; lower jaw slightly shorter than upper; teeth conical, in a single series in both jaws; first gill arch has 6 or 7 + 22 or 23 fairly short gill rakers, the longest shorter than eye; the barbels extend to a little behind angle of entire preopercle; opercle armed posteriorly with two spines, upper one very small and rather inconspicuous; least depth of caudal peduncle 2.7 to 3 times in head; scales ctenoid and rather large; head completely covered with scales, excepting the partially naked preorbital.

Third or fourth dorsal spine highest, 1.4 to 1.5 times in head, first spine very small; second dorsal slightly lower than anal,

which is 2.5 to 2.7 times in head; pectoral a little shorter than ventral, which is 3.8 to 4.2 times in length of body; caudal fin slightly longer than ventral, 3.5 to 3.6 times in length.

In life the ground color is pink, becoming paler below; a black rounded blotch on lateral line below the space between the two dorsals; immediately behind this blotch a larger, oblong, yellow area; dorsal spines pink, membranous portions yellowish; soft dorsal with a black basal blotch, its outer portion longitudinally barred with alternating yellowish and pink-edged whitish stripes; caudal yellowish brown, narrowly margined above with pink and broadly washed below with the same color; the anal has alternating yellow and pinkish longitudinal bands; the pectoral is pink and has a darker blotch at base, the ventrals much paler; several very pale lavender lines radiate forward, upward, and backward from eye; a longitudinal line of like color across orbital ring; barbels pinkish.

Color in alcohol dull whitish to yellow brown, with a rounded blackish spot on lateral line below the space between first and second dorsals, and a yellow oblong blotch immediately behind it; second dorsal blackish at its basal half, its outer portion yellowish, with rather faint longitudinal stripes of brown-violet; spinous dorsal almost colorless; caudal yellowish, indistinctly edged below with brownish; the other fins yellowish, unmarked; no traces of the very pale lavender lines from eye.

Here described from three specimens, 162 to 200 millimeters long, from Zamboanga, Mindanao. We also have an example from Honolulu.

This species, which was originally described from Banda Neira, was also recorded by Bleeker from Amboina. This is a very widely distributed goatfish; it is not rare at Zanzibar and Mauritius, and is common in the Hawaiian Islands. It is also known from the Gilbert Islands and from Tahiti.

UPENEUS CYCLOSTOMUS (Lacépède). Plate 6, fig. 3.

Mullus cyclostomus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 404, pl. 19, fig. 3.

Upeneus cyclostomus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1831) 348.

Upeneus cyclostoma RÜPPELL, Neue Wirbelt., Fische (1835) 101.

Parupeneus cyclostomus BLEEKER, Ned. Tijds. Dierk. 2 (1865) 285.

Pseudupeneus cyclostomus JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 275.

Dorsal VIII–I, 9; anal I, 7; scales $2\frac{1}{2}$–28 + 2–$6\frac{1}{2}$.

Body rather deep and notably compressed, its greatest depth at origin and anterior base of first dorsal, 3.2 to 3.3 times in length; the pointed head much longer than deep, 2.7 times in length; the convex interorbital 4.4 times in length; the small eye in posterior half of head, 3.6 to 3.7 times in snout, 6.4 to 6.5 in head; the elongate, pointed snout 1.8 times in head, its upper outline straight or very slightly concave; maxillary 1.5 to 1.6 times in snout or 2.7 to 2.8 times in head, very broad posteriorly, and reaching to a vertical midway between anterior and posterior nostrils; lower jaw slightly included; teeth conical and rather small, in a single series in each jaw; first gill arch has 5 + 22 gill rakers, the longest slightly greater than half the eye; the barbels very long and slender, reaching to base of ventrals, 3 to 3.1 times in length of body; a single spine at hind border or opercle; least depth of caudal peduncle 3.1 times in head; large, finely ctenoid scales cover head and body, none present on preorbital and on anterior portion of snout.

Second and third dorsal spines about equal in height, each 1.6 times in head, first spine very small; soft dorsal and anal equal in height, their first rays the highest, 2.9 to 3.1 times in head, the latter fin having a minute spine; the ventral, which is slightly longer than pectoral, is 1.7 times in head and ends at second scale before anus; upper lobe of the deeply forked caudal slightly longer than lower, 3.2 to 3.4 times in length of body.

The color of the specimens when fresh was clear orange red, slightly deeper above, without markings anywhere on body.

In alcohol the fish is uniformly yellowish white, the fins concolorous.

We have two large examples of this species, 220 and 225 millimeters long, taken by Japanese fishermen by the muroami method at Tablas and Sibuyan Islands.

This species is here recorded for the first time from the Philippines; it occurs in the East Indies and Samoa. It is characterized by its notably compressed deep body, small eye, long snout, long barbels, and the absence of a yellow saddle on caudal peduncle.

UPENEUS MOANA (Jordan and Seale). Plate 4, fig. 2.

Pseudupeneus moana JORDAN and SEALE, Bull. Bur. Fisheries **25** (1906) 274; SEALE, Occ. Papers Bishop Mus. **4** (1906) 48; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907); SEALE and BEAN, Proc. U. S. Nat. Mus. **33** (1907) 245.

Upeneus trifasciatus GÜNTHER, Fische der Südsee 1 (1873) 59, pl. 44, fig. B.

Upeneus multifasciatus SEALE, Occ. Papers Bishop Mus. 1 (1901) 71; ? FOWLER, Proc. U. S. Nat. Mus. 62 (1922) 44.

Parupeneus multifasciatus BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 20; Atlas Ichth. 9 (1878) pl. 394, fig. 4.

Dorsal VIII–I, 8; anal I, 6; scales 2–28 to caudal base–6.

Greatest depth of body at origin of first dorsal, 3.2 to 3.4 times in length, upper profile strongly convex; the compressed head 2.9 to 3.1 times in length, upper outline nearly straight or slightly concave before eyes; interorbital space very convex, its least width greater than eye, 3.4 to 4 times in head; eye rather small, 4.8 to 6.2 times in head; snout elongate and pointed, 1.7 to 1.9 times in head or 2.7 to 3.7 times eye; maxillary very broad posteriorly, reaching a vertical through middle of distance between anterior and posterior nostrils; jaws even, with very thick and broad lips; the bluntish conical teeth widely spaced, in a single series in each jaw; gill rakers 7 to 9 + 27 to 29; the long barbels extend to origin of ventrals, each about twice the length of maxillary or 3.6 to 4.1 times in that of body; edges of preopercle smooth; two spines on hind edge of opercle, the upper very much the smaller; depth of caudal peduncle 2.6 to 2.9 times in head; scales rather large, weakly ctenoid; head completely scaled excepting the naked lips and preorbital.

Third dorsal spine highest, 1.4 to 1.7 times in head; the last rays of soft dorsal and anal prolonged, the former slightly the higher, 1.6 to 2.9 times in head; pectoral equals distance from tip of snout to vertical edge of preopercle, 4.2 to 4.8 times in length of body; ventral slightly longer than pectoral and reaching to anus; the deeply forked caudal 3.5 to 3.9 times in length of body, its lobes obtusely pointed.

In life the general color is pinkish red, the scales above darker and edged with yellow; four darker crossbands on each side of body, the last on caudal peduncle and separated from third by a wide yellow saddle; first dorsal clouded with dusky, second dorsal black at basal half and with violet and yellow longitudinal stripes on its outer portion; anal barred longitudinally with alternating violet and yellow; ventral red, edged anteriorly with blackish; pectoral uniformly golden orange; caudal brownish, edged with black above and below; barbels golden; three of four blue or drab lines covering each side of snout, and four bluish

lines extending backward from eye; lower portion of head deep pink.

Ground color in alcohol purplish above, yellowish below; a blackish horizontal band on snout, continued through eye to a little distance behind it; three well-defined broad blackish bands on each side of trunk, descending from back to below lateral line, the first rather faint, below spinous dorsal; it may be preceded by two more or less indistinct ones, sometimes appearing as one; the second band, a little narrower and darker, descends between the two dorsals; the third band is below anterior portion of second dorsal; behind it is a wide yellow area; a broad saddle of black forms a fourth band on caudal peduncle; spinous dorsal slightly dusky; basal half of second dorsal black, outer half with blackish longitudinal bands; anal yellowish, banded longitudinally with blackish; anterior portions of ventrals dusky, and upper and lower edges of caudal dusky; pectoral uniformly yellowish.

The above account is taken from the following specimens, 45 to 190 millimeters in length:

Santo Domingo de Basco, Batanes Province, 1.
Camp Wallace, La Union, 4.
Subic Bay, 1.
Monja Island, outside the entrance to Manila Bay, 3.
Hamilo, Batangas, 5.
Calapan and Puerto Galera, Mindoro, 7.
Sibuyan Island, 1.
Bantayan Island, 1.
Agutaya Island, 1.
Jordan, Guimaras, 1.
Puerto Princesa, Palawan, 1.
Zamboanga, Mindanao, 4.
Samal Island, Davao, 1.

The three examples from Monja Island, collected April 23, 1922, are females nearly ready to spawn. They are 127 to 172 millimeters in length.

Evermann and Seale had a specimen from Bacon, Sorsogon, and Seale and Bean had three specimens from Zamboanga. Fowler and Bean had two specimens from Zamboanga, which they called *Upeneus multifasciatus*.

This species has been confused with other banded goatfishes, from all of which it is separated by the presence of a bright yellow area in alcoholic specimens, between the black saddle on the caudal peduncle and the black band descending from the soft dorsal. It is widely distributed in the tropical Pacific, and occurs everywhere from the East Indies to Guam, the Austral and Marquesas Islands.

UPENEUS CHRYSERYDROS (Lacépède). Plate 5, fig. 3.

Mullus chryserydros LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 406.

Upeneus chryserydros CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 346.

Upeneus chryserythrus GÜNTHER, Fiche der Südsee 1 (1873) 60, pl. 45, fig. A.

Upeneus chryseredros JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 260.

Parupeneus cherserydros BLEEKER, Natuurk. Verh. Kon. Acad. Amsterdam 15 (1875) Révis. Mulloides 35; Atlas Ichth. 9 (1878) pl. 393, fig. 2; WEBER, Fische, Siboga Exp. (1913) 296.

Parupeneus chryserythrus KLUNZINGER, Fische de Rothen Meeres (1855) 52.

Pseudupeneus chryserydros JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 255, fig. 106; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 275.

Upeneus oxycephalus BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Vischs. Manado, 45; GÜNTHER, Cat. Fishes 1 (1859) 409.

Dorsal VIII–I, 8; anal I, 7; scales $2\frac{1}{2}$–26 + 3–$6\frac{1}{2}$.

Body long, with the back considerably elevated, its greatest depth at base and origin of spinous dorsal, 3.5 times in length; the long pointed head much longer than deep, 2.9 to 3 times in length, its upper outline low and evenly curved from anterior end of snout to origin of first dorsal; interorbital space moderately convex, its least width 3.9 to 4.2 times in head; the small eye in posterior half, 5.5 to 6 times in head; the long bluntly pointed snout nearly straight above, 1.7 to 1.8 times in head or 3.1 to 3.4 times eye; maxillary is broadest posteriorly and extends to a little past a vertical midway between anterior and posterior nostrils, very slightly more than twice eye; jaws approximately equal, with thick fleshy lips; teeth bluntly conical and rather widely spaced, in a single row in each jaw; 6 + 21 to 23 moderately slender gill rakers on first arch, the longest a trifle greater than half eye; barbels elongate, reaching to base of ventrals, each 3.4 to 3.5 times in length of body; third dorsal spine longest, 1.6 to 1.7 times in head, first spine very short; second dorsal 2.5 to 2.8 times in head, and about as high as anal, which has a minute rather inconspicuous spine in front; ventral fin longer than pectoral, which is 1.6 to 1.7 times in head and extends to a vertical midway between the two dorsals; caudal fin deeply forked, about as long as the barbels, contained 3.5 to 3.6 times in total length.

According to Jordan and Richardson, this fish in life is white below and bluish above, with a rosy wash on opercle, preopercle, and tail, and with a yellow saddle on caudal peduncle; several

lines of dark yellow and lavender run from snout through eye, and a number of lines radiate from upper side of eye; the rays of spinous dorsal lavender in color, the membranes yellow; second dorsal irregularly striped with lemon yellow and lavender; pectorals and ventrals clear. Smaller specimens uniformly yellow, darker above, a little paler below, and brighter on the fins.

An example from Zamboanga was bright yellow in life, with a whitish saddle on the caudal peduncle immediately behind the soft dorsal, the fins orange red.

According to Jordan, this species is well distinguished by its peculiar violaceous coloration, like the lees of wine as Commerson, its discoverer, phrased it. Jordan and Evermann describe a living specimen as dark leaden purple, shaded with red on side; a large conspicuous orange-yellow blotch on caudal peduncle above; another one was purplish rose inclining to red rather than the usual livid purplish lead color; back of tail bright golden shaded with orange. In the Honolulu market its livid purplish colors contrast strongly with those of other species of goatfishes.

In alcohol the color of the body and fin is uniformly yellowish to yellowish brown, with a conspicuous paler saddle on the caudal peduncle.

There are two examples of this species in the Bureau of Science collection, measuring 166 and 211 millimeters in length. They were collected at Zamboanga, Mindanao.

This beautiful species, which reaches a length of 380 millimeters, is widespread, occurring from the Red Sea to the Hawaiian, Samoa, and Society Islands.

UPENEUS PLEUROSPILOS Bleeker. Plate 1, fig. 2.

Upeneus pleurospilos BLEEKER, Nat. Tijds. Ned. Ind. 4 (1853) 110; Verh. Bat. Gen. 26 (1854–1857) 69; GÜNTHER, Cat. Fishes 1 (1859) 407; MEYER, Ann. Soc. España Hist. Nat. 14 (1885) 16.

Parupeneus pleurospilos BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 31; Atlas Ichth. 9 (1878) pl. 191, fig. 5.

Pseudupeneus pleurospilos SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 96.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–28 + 3–$5\frac{1}{2}$.

Body rather deep, its greatest depth at origin of first dorsal and base of anterior dorsal spines, 3.4 to 3.5 times in length; upper profile evenly arched from snout to spinous dorsal; head

3 to 3.1 times in length of body; least width of the convex interorbital 3.6 to 3.8 times in head; eye moderate in size, 3.8 to 4.6 times in head and very slightly nearer posterior margin of opercle than tip of snout; snout moderate, 1.8 to 2.3 times in head; maxillary extends nearly below posterior nostril, 2.4 to 2.8 times in head; mouth slightly oblique, with jaws even; a single row of conical, rather widely spaced teeth in each jaw; 6 + 21 or 22 gill rakers on first arch, the longest about equal to or a trifle more than half eye; the long slender barbels extend almost to base of ventrals, 3.7 to 4.3 times in length of body; preopercle entire, opercle armed posteriorly with two spines; least depth of caudal peduncle 2.9 times in length of head; no scales on preorbital, those on remaining portions of head and body moderate in size.

Second and third dorsal spines highest, 1.7 times in head, the first one very small; second dorsal and anal equal in height, 2.3 to 2.9 times in head; pectoral 1.3 to 1.6 times in head, slightly shorter than ventral which is 1.5 times; the deeply forked caudal 3.3 to 3.6 times in length of body, with the lower lobe a trifle the shorter.

Two of our specimens are more or less rose colored, but the rest are uniformly yellowish to yellowish olive, with a blackish spot between lateral line and posterior half of pectoral; three pearly bluish bands on snout and head, the first along upper edge of eye, the second opposite middle of eye, the third along lower edge of eye; the second dorsal has two logitudinal lines; anal and caudal indistinctly barred with brown, the other fins colored as body. In life this species is rose colored, darker above, paler below.

Here described from the following examples, 64 to 130 millimeters long: Polillo, 2; Calapan, 1; Cebu, Cebu, 1; Cagayan de Misamis, 3; and Davao, Mindanao, 1.

This species differs from *Upeneus pleurostigma* Bennett, which it closely resembles, in having the lateral black spot more anterior and not followed by a yellow area, in having stripes on head and snout, and in having the soft dorsal, anal, and caudal barred. It was first recorded in the Philippines by Meyer from Cebu. Bleeker had specimens from Amboina, Bali, and Saparoua in the East Indies, and Nagasaki, Japan. It must be rather rare, as no record of it has been published since the records of Bleeker and Meyer.

Genus MULLOIDES Bleeker

Mulloides BLEEKER, Verh. Bat. Gen. 22 (1849) 12.

The small acute teeth are in several rows or form a narrow band in both jaws; none on vomer and palatines. Head convex, the obtuse snout scaled, opercle terminating in a flat spine.

A dozen or more species are known, mostly confined to the tropical Pacific.

Key to the Philippine species of Mulloides.

a^1. Body with a longitudinal band or bands.
  b^1. A yellow band from snout or eye to caudal.
    c^1. A conspicuous yellow band on fresh and preserved specimens; depth 3.5 to 3.8 in length; maxillary 2.7 to 2.8 in head. **M. auriflamma.**
    c^2. Fresh specimens with a bright yellow stripe from eye to caudal, a narrow one above; two or three below it on head; none present on alcoholic specimens; a blackish blotch usually present below lateral line; depth 4.1 to 4.6; maxillary 3.3 to 3.4 in head. **M. samoensis.**
  b^2. An indistinct dusky line from head to caudal; three or four oblique dusky bands on caudal; depth 3.85 to 4.4 in length..... **M. japonicus.**
a^2. Body uniform in color.
  e^1. Caudal not barred.
    f^1. Fresh specimens reddish above, yellow below; preserved ones yellowish, dorsal region and top of head brown; no lateral spot, depth 3.6 to 3.9 in length; maxillary 2.8 to 3 in head. **M. vanicolensis.**
    f^2. Alcoholic specimens uniformly yellowish white to yellowish brown; a blackish lateral spot often present; depth 4.1 to 4.6 in length; maxillary 3.3 to 3.4 in head..... **M. samoensis.**
  e^2. Caudal with three or four oblique dusky bands; lateral band often disappearing, specimens then brownish above, silvery below; depth 3.85 to 4.4 in length..... **M. japonicus.**

MULLOIDES AURIFLAMMA (Forskål). Plate 2, fig. 3.

Mullus auriflamma FORSKÅL, Descr. Anim. (1775) 30.

Upeneus auriflamma CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 339.

Mulloides auriflamma KLUNZINGER, Verh. Zool. Bot. Ges. Wien 20 (1870) 742; STEINDACHNER, Denkschr. Akad. Wiss. Wien 70 (1900) 485; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 250, fig. 103; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 276; Proc. U. S. Nat. Mus. 28 (1905) 782; SEALE, Occ. Papers Bishop Mus. 4 (1906) 48; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 44.

Mullus flavolineatus LACÉPÈDE, Hist. Nat. Poiss. 3 (1801) 406.

Upeneus flavolineatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 336; RÜPPELL, Neue Wirbelt., Fische (1835) 101, pl. 26, fig. 1.

Mulloides flavolineatus BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 697; GÜNTHER, Cat. Fishes 1 (1859) 403; Fische der Südsee 1 (1873) 56; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 15; DAY, Fishes of India (1878) 122, pl. 30, fig. 6; BLEEKER, Atlas Ichth. 9 (1878) pl. 394, fig. 3; SEALE, Occ. Papers Bishop Mus. 1 (1901) 71.

Upeneus zeylonicus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 338.

Mulloides zeylonicus BLEEKER, Act. Soc. Sci. Ind. Neerl. 6 (1859) 8; Verh. Akad. Amsterdam 15 (1875) Révis. Mulloides, 16.

Dorsal VII–I, 8; anal I, 6; scales $2\frac{1}{2}$–36 + 3 or 4–$6\frac{1}{2}$.

Body somewhat slender, its greatest depth at base of spinous dorsal, 3.5 to 3.8 times in length, upper profile evenly arched; head notably longer than deep, 3.2 to 3.3 times in length of body; the very slightly convex interorbital space somewhat wide, its least width 3.1 to 3.4 times in head; the large eye a little nearer to posterior edge of opercle than to tip of snout, 3.7 to 3.9 times in head or 1.6 to 1.9 times in the rather short snout, which is slightly arched above and 2 to 2.2 times in length of head; maxillary very wide posteriorly, 2.7 to 2.8 times in head; the very wide preorbital forms a rather deep notch with the extremely narrow suborbital; jaws even, with thick and broad lips; teeth very small, in several series in each jaw; first gill arch with 8 + 23 or 24 gill rakers (7 + 18 according to Fowler and Bean), not longer than half eye, on first arch; the barbels touch the vertical limb of the smooth preopercle; only one spine at hind edge of opercle; least depth of caudal peduncle 2.7 to 3.2 times in head; scales finely and weakly ctenoid, none present on preorbital.

First dorsal spine highest, not much higher than second and contained 1.4 to 1.5 times in head; second dorsal equals anal in height, 1.8 to 2.3 times in head; ventral fin extends to vertical from axil of first dorsal and is as long as pectoral, which is 1.4 to 1.6 times in head; caudal is deeply forked and almost equals head in length.

An example from Puerto Galera was yellowish white in life, a little darker above; it had a lemon yellow longitudinal stripe from snout to caudal; the cheeks had some lemon yellow dots; dorsals and caudal lemon yellow, the other fins whitish overlaid with pink.

Another example, from Tablas Island, when fresh was pinkish yellow, with a bright lemon yellow longitudinal band from eye to base of caudal; head pinkish red above and yellowish pink

below; pectoral very pale pink, all the other fins light orange yellow; the barbels were pinkish.

Alcoholic specimens are deep brown above, yellowish to yellowish brown on sides and abdomen; the yellow longitudinal band on each side of body quite conspicuous; the barbels and all the fins yellowish, unmarked.

Here described from eleven examples, 83 to 260 millimeters long, taken at Luna, La Union; Monja Island, Corregidor; Puerto Galera and Calapan, Mindoro; Tablas; Dicuayan Island, Busuanga; and Bungau and Banaran Islands, Sulu Archipelago.

Jordan and Seale had two specimens from the southern coast of Negros and Fowler and Bean had two from Zamboanga. This species was originally described from the Red Sea and occurs southward to Madagascar, île de France, Ceylon, and the Adamans in the Indian Ocean. It occurs in the East Indies, particularly in the Moluccas, and is abundant throughout the tropical Pacific, from Guam and Hawaii to Samoa, the Austral Islands, Tahiti, and the Marquesas. It reaches a length of 300 millimeters and is an important food fish.

MULLOIDES SAMOENSIS Günther. Plate 3, fig. 4.

Mulloides samoensis GÜNTHER, Fische der Südsee 1 (1873) 57, pl. 43, fig. B; JENKINS, Bull. U. S. Fish Comm. 22 (1903) 453; SNYDER, Bull. U. S. Fish Comm. 22 (1903) 527; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 [1] (1905) 253, fig. 105; SEALE, Occ. Papers Bishop Mus. 4 (1906) 47; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 87; WEBER, Fische, Siboga Exp. (1913) 294.

The name in Pangasinan is *tubac;* in Tagalog, *tuyo.*

Dorsal VIII–I, 9; anal I, 7; scales $2\frac{1}{2}$–35 + 3–$6\frac{1}{2}$.

The greatest depth of the elongate slender body is at origin and anterior end of spinous dorsal, 4.1 to 4.6 times in length; head much longer than deep, 3.1 to 3.3 times in length, its upper profile evenly arched; interorbital space nearly flat, its least width 3.1 to 3.6 times in head; eye large, 3.7 to 4.5 times in head, located nearer posterior edge of opercle than tip of snout; snout bluntly pointed, steep above, 1.9 to 2.1 times in head or 1.8 to 2.2 times eye; maxillary 1.6 to 1.8 times in snout or 3.3 to 3.4 times in head, extending to a perpendicular halfway between anterior and posterior nostrils; mouth rather small, nearly horizontal, with lower jaw a little included; teeth in a villiform band in each jaw; first gill arch contains 7 or 8 + 18 to 20 short, rather stout gill rakers; barbels 1.5 to 1.7 times in head, reaching

to vertical margin of smooth preopercle; opercle armed posteriorly with a single spine; least depth of caudal peduncle 3.1 to 3.4 times in head; scales large, finely ctenoid, completely covering head with the exception of the naked preorbital.

First dorsal spine highest, 1.4 to 1.7 times in head and slightly higher than second; soft dorsal and anal slightly concave, the latter a trifle lower, 2.5 to 2.6 times in head; pectoral and ventral equal in length, 1.4 to 1.7 times in head; the deeply forked caudal equal to or shorter than head, 3.3 to 3.6 times in length of body.

In life this fish is white below and gray-drab above; a bright yellow longitudinal stripe runs from eye to base of caudal; above this stripe is a narrower and less-distinct one and below it are two or three yellow longitudinal lines on each side of snout and two others on check; the pinkish red opercle edged posteriorly with yellow; dorsal whitish orange anteriorly; both soft dorsal and caudal yellow, the latter pinkish red at its base; the remaining fins whitish, with a slight wash of pinkish on their membranes; the pectoral has a reddish bar at its base; an obscure blackish blotch is oftentimes present immediately below the lateral line at about posterior third of pectoral.

Alcoholic specimens are uniformly yellowish white to yellowish brown; no trace is left of the yellow longitudinal stripes on sides; the blackish spot below spinous dorsal immediately under lateral line is present in many of the examples; all the fins are colored like the body.

Here described from fifty-four specimens, 70 to 253 millimeters in length, from the following localities:

Manila, 1.
Bacon, Sorsogon, 1.
Romblon, 1.
Borongan, Samar, 1.
Cebu, Cebu, 1.
Camiguin Island, Misamis, Mindanao, 2.
Samal Island and Davao, Mindanao, 3.
Caldera Bay and Zamboanga, Mindanao, 7.
Guam, 37.

Evermann and Seale recorded this species from San Fabian, Pangasinan, and Bacon, Sorsogon. It was originally described from Samoa where it is common, later from Hawaii where it is equally abundant. It has been collected at the Marquesas, Tahiti, the New Hebrides, and Salibabu, one of the Karkelong Islands, south of Mindanao. It is one of the larger goatfishes, reaching a length of a third of a meter.

MULLOIDES JAPONICUS (Houttuyn).

Mullus japonicus HOUTTUYN, Verh. Holl. Maat. Weet. Haarlem 20[2] (1782) 334.

Upeneus japonicus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 3 (1829) 339.

Mulloides japonicus GÜNTHER, Cat. Fishes 1 (1859) 404; SNYDER, Proc. U. S. Nat. Mus. 32 (1907) 96; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 88; JORDAN and HUBBS, Mem. Carnegie Mus. 10 (1925) 246.

Dorsal VIII or VII–I, 8; anal I, 6; scales 3–37–5.

Depth 3.85 to 4.4, head 3.5 times in length; eye 3.5 times in head, slightly nearer tip of snout than margin of opercle; interorbital space not strongly convex, its width equal to eye; the pointed snout 2.6 times in head, the jaws equal; about two-thirds of upper margin of maxillary concealed by preorbital, its evenly rounded posterior end not quite reaching a vertical through anterior margin of orbit, its length 3.33 times in head; the minute teeth in two or three rows in upper jaw, in a narrow band in lower jaw; the barbels extend to posterior margin of preopercle; angle of opercle has a small flat spine, preopercle entire; head, including snout, maxillary, and chin, covered with scales; dorsal spines very slender, the first longest, 1.5 times in head, apparently not preceded by a minute embedded spine; soft dorsal and anal of equal height, the longest ray 2.2 times in head; lobes of caudal acutely pointed, about equal to length of head; ventrals slightly longer than pectoral, 1.4 times in head; tubes of lateral line with three or four branches; pseudobranchiæ large; gill rakers 7 + 23, long and slender; peritoneum dusky.

Color in alcohol brownish above, silvery below. The above description is taken from Snyder, as we have seen no specimen. Evermann and Seale had four specimens, "4.75 inches in length," from Bulan, Sorsogon. Otherwise it has only been recorded from Japan, and is not abundant there.

Evermann and Seale state "3 or 4 dusky oblique bands on caudal, almost obliterated on lower lobe, an indistinct dusky line on side from head to caudal." Their specimens were compared with authentic specimens from Japan.

Jordan and Hubbs state that in all their material, obtained at Kagoshima, the dorsal spines are seven, not eight as found by Snyder in his two specimens from Misaki. They report an additional minute spine in front of these as sometimes present but often absent. They give the color as "bright yellow, be-

coming pink along the middle of the sides, above the large blackish opercular blotch, along the anterior free margin of the subopercle (which otherwise, like the interopercle, is silvery) and on the postorbital region."

MULLOIDES VANICOLENSIS (Cuvier and Valenciennes). Plate 1, fig. 3.

Upeneus vanicolensis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 391; SMITH and SWAIN, Proc. U. S. Nat. Mus. 5 (1882) 131.

Mulloides vanicolensis BLEEKER, Nat. Tijds. Ned. Ind. 4 (1853) 601; GÜNTHER, Cat. Fishes 1 (1859) 404; BLEEKER, Natuurk. Verh. Kon. Akad. Amsterdam 15 (1875) Révis. Mulloides 14; Atlas Ichth. 9 (1878) pl. 392, fig. 6; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 254; WEBER, Fische, Siboga Exp. (1913) 294.

Dorsal VIII–I, 8; anal I, 6; scales $2\frac{1}{2}$–37 + 3–$6\frac{1}{2}$.

Body slender, deepest at base and origin of spinous dorsal, its depth 3.6 to 3.9 times in length; dorsal outline gently and evenly curved from snout to second dorsal and not much more elevated than ventral contour; head much longer than deep, 3.3 to 3.4 times in length of body; interorbital space moderately convex, about as wide as the large eye, which is 3.2 to 3.4 times in head and located a little nearer to posterior margin of opercular bone than to tip of snout; the short, bluntish snout 1.3 to 1.5 times eye or 2.2 to 2.5 times in head; maxillary very broad posteriorly, 2.8 to 3 times in head, extending to below anterior rim of orbit; the small mouth slightly oblique, with nearly even jaws; teeth in both jaws in villiform bands; 8 + 22 to 24 gill rakers on first arch, the longest less than half eye; the slender barbels 1.4 to 1.5 times in head, extending to vertical edge of the smooth preopercle; opercle armed at its hind border with a single spine; caudal peduncle tapers posteriorly, its least depth 2.7 to 2.8 times in head; scales moderate in size, ctenoid, absent on preorbital.

First dorsal rather high, 1.4 times in head, its first spine minute, second higher than the rest; second dorsal and anal a little concave above, equal in height, 2 to 2.1 times in head, their first rays higher than the others; ventral ends below axil of spinous dorsal and is a little longer than pectoral, which is 1.4 to 1.5 times in head; caudal fin is deeply forked and equals head in length.

Ground color in alcohol yellowish; top of head and upper portions of its sides deep brown; all the fins yellowish, the caudal with brownish tips.

Here described from three specimens, 106 to 183 millimeters in length, from Zamboanga, Mindanao, and Tambagaan Island, Sulu Archipelago. The only other Philippine record is that by Evermann and Seale, who had two specimens from Zamboanga.

This species does not have a golden longitudinal band on each side of the body, thus differentiating it from *Mulloides auriflamma* (Forskål) which it otherwise resembles very closely. It reaches a length of 250 millimeters.

This seems to be a rather rare mullet. Cuvier and Valenciennes described it from material collected by Quoy and Gaimard at Vanicolo, one of the Santa Cruz Islands; Smith and Swain had it from Johnson Island, an outlying dependency of the Hawaiian Islands, far to the southwest of Honolulu. In the east Indies it has been found in but few localities, all in the Moluccas and northward to Mindanao, and the Sulu Archipelago.

SUMMARY OF THE PHILIPPINE GOATFISHES, OR MULLIDÆ, DESCRIBED IN THIS PAPER

1. Genus UPENEOIDES Bleeker

1. **luzonius** (Jordan and Seale).
2. **sundaicus** Bleeker.
3. **tragula** (Richardson).
4. **moluccensis** Bleeker.
5. **sulphureus** (Cuvier and Valenciennes).
6. **vittatus** (Forskål).

2. Genus UPENEUS Cuvier

7. **barberinus** (Lacépède).
8. **dispilurus** Playfair.
9. **luteus** Cuvier and Valenciennes.
10. **indicus** (Shaw).
11. **spilurus** Bleeker.
12. **bifasciatus** (Lacépède).
13. **barberinoides** Bleeker.
14. **pleurostigma** Bennett.
15. **cyclostomus** (Lacépède).
16. **moana** (Jordan and Seale).
17. **chryserydros** (Lacépède).
18. **pleurospilos** Bleeker.

3. Genus MULLOIDES Bleeker

19. **auriflamma** (Forskål).
20. **samoensis** Günther.
21. **japonicus** (Houttuyn).
22. **vanicolensis** (Cuvier and Valenciennes).

ILLUSTRATIONS

PLATE 1

FIG. 1. *Upeneoides luzonius* (Jordan and Seale). (Drawing by Pablo Bravo.)
2. *Upeneus pleurospilos* (Bleeker). (Drawing by Pablo Bravo.)
3. *Mulloides vanicolensis* (Cuvier and Valenciennes). (Drawing by A. L. Canlas.)

PLATE 2

FIG. 1. *Upeneus indicus* (Shaw). (Drawing by A. L. Canlas.)
2. *Upeneoides tragula* (Richardson). (Drawing by A. L. Canlas.)
3. *Mulloides auriflamma* (Forskål). (Drawing by Pablo Bravo.)

PLATE 3

FIG. 1. *Upeneoides sulphureus* (Cuvier and Valenciennes). (Drawing by Pablo Bravo.)
2. *Upeneus dispilurus* Playfair. (Drawing by A. L. Canlas.)
3. *Upeneus barberinus* (Lacépède). (Drawing by Pablo Bravo.)
4. *Mulloides samoensis* Günther. (Drawing by A. L. Canlas.)

PLATE 4

FIG. 1. *Upeneoides vittatus* (Forskål). (Drawing by Pablo Bravo.)
2. *Upeneus moana* (Jordan and Seale). (Drawing by Pablo Bravo.)
3. *Upeneus barberinoides* Bleeker. (Drawing by A. L. Canlas.)

PLATE 5

FIG. 1. *Upeneus luteus* Cuvier and Valenciennes. (Drawing by Pablo Bravo.)
2. *Upeneus pleurostigma* Bennett. (Drawing by Pablo Bravo.)
3. *Upeneus chryserydros* (Lacépède). (Drawing by A. L. Canlas.)

PLATE 6

FIG. 1. *Upeneoides moluccensis* Bleeker. (Drawing by A. L. Canlas.)
2. *Upeneus bifasciatus* (Lacépède). (Drawing by Pablo Bravo.)
3. *Upeneus cyclostomus* (Lacépède). (Drawing by Pablo Bravo.)

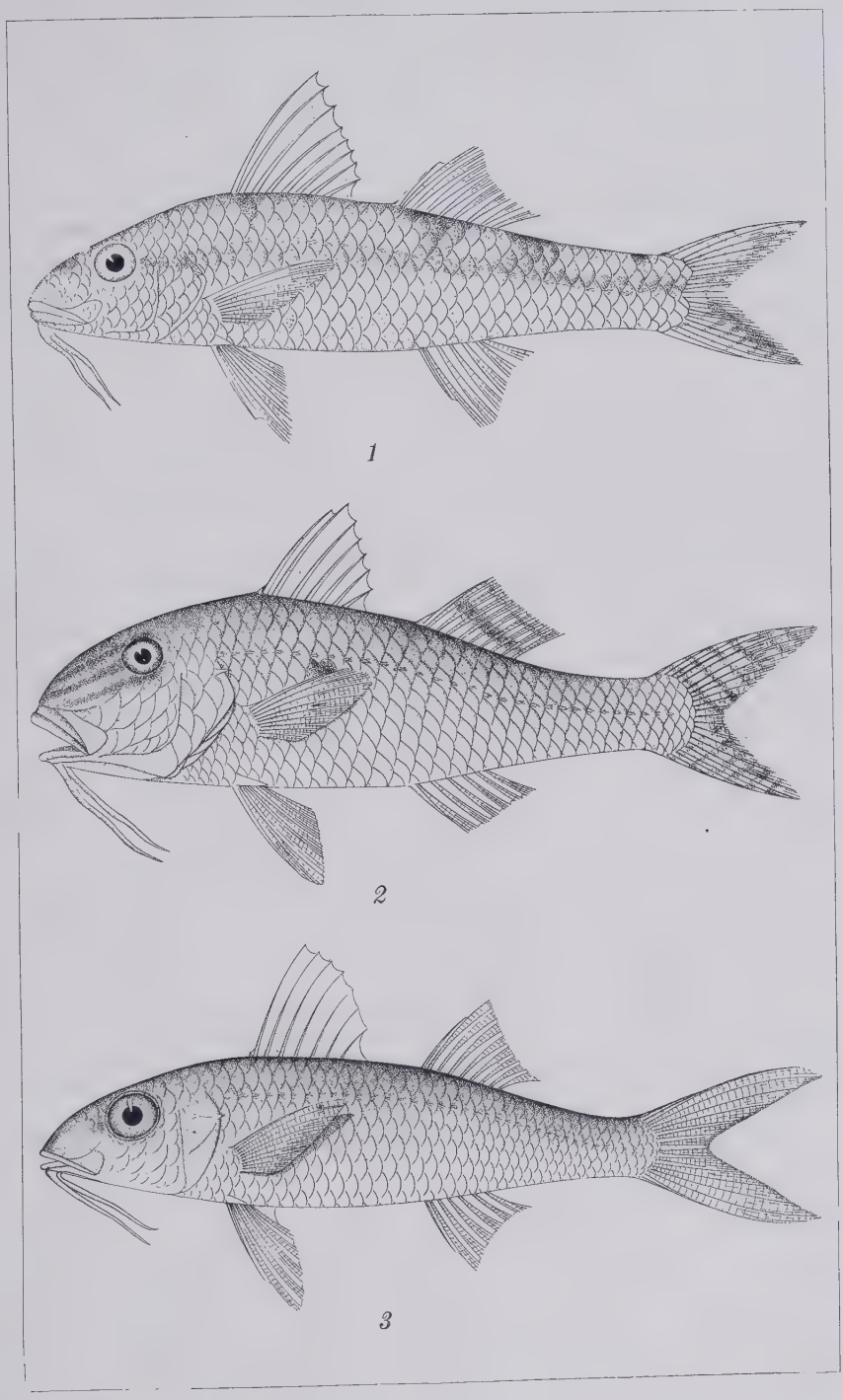

PLATE 1.

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PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

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PLATE 6.